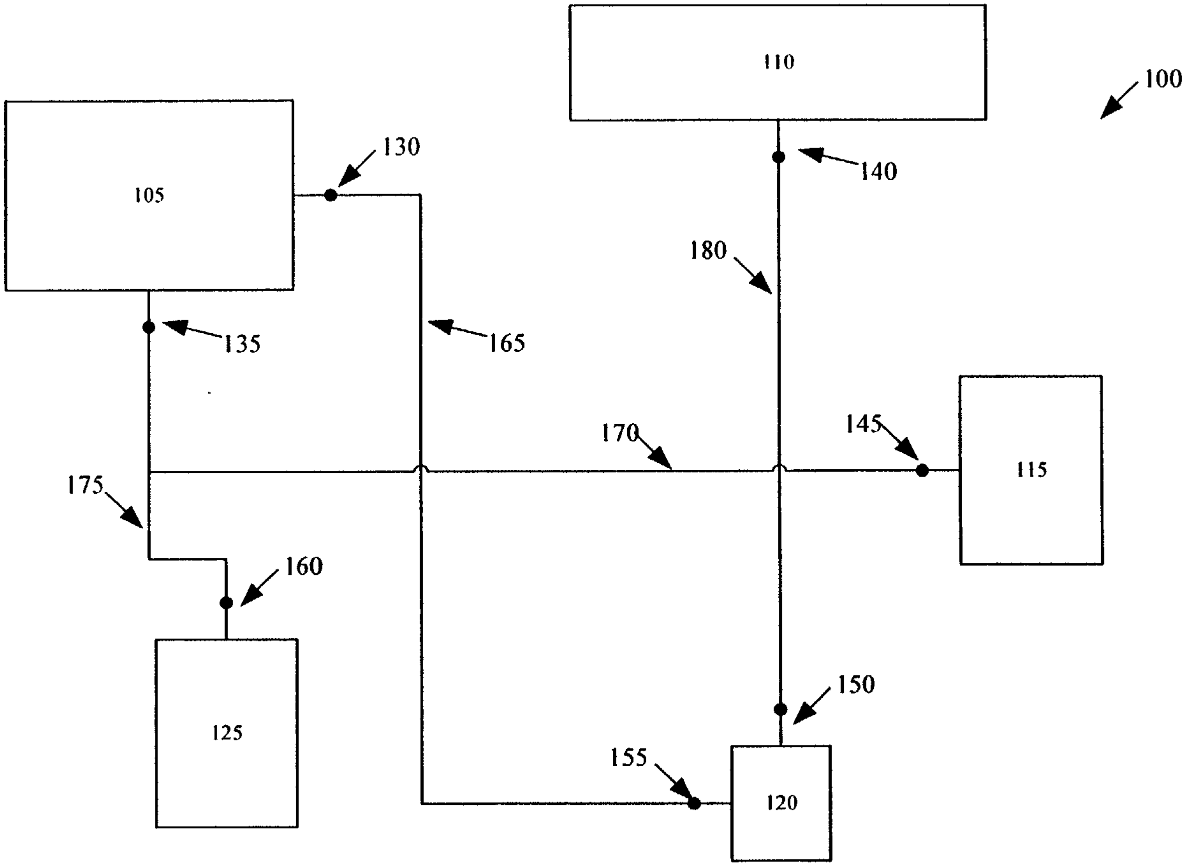

100
110
105
130
140
180
135
165
170
145
115
175
160
150
125
155
120

Figure 1

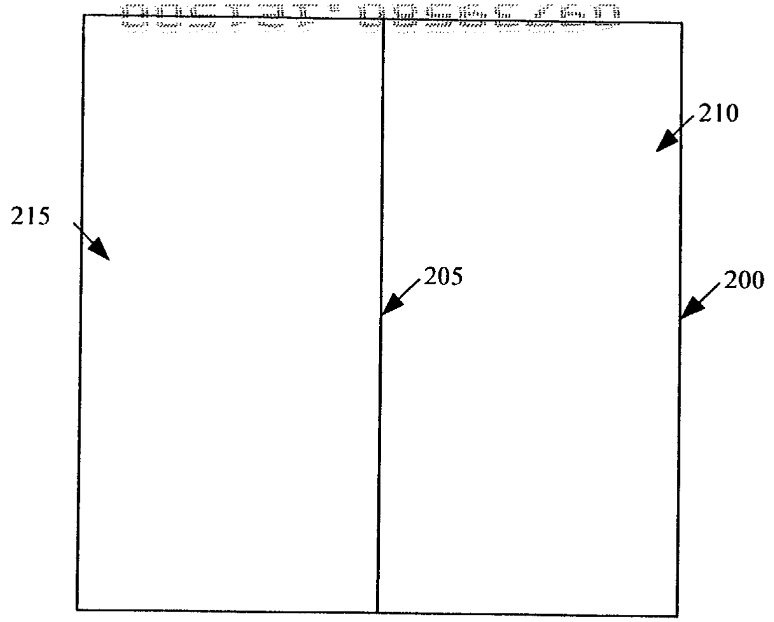


Figure 2

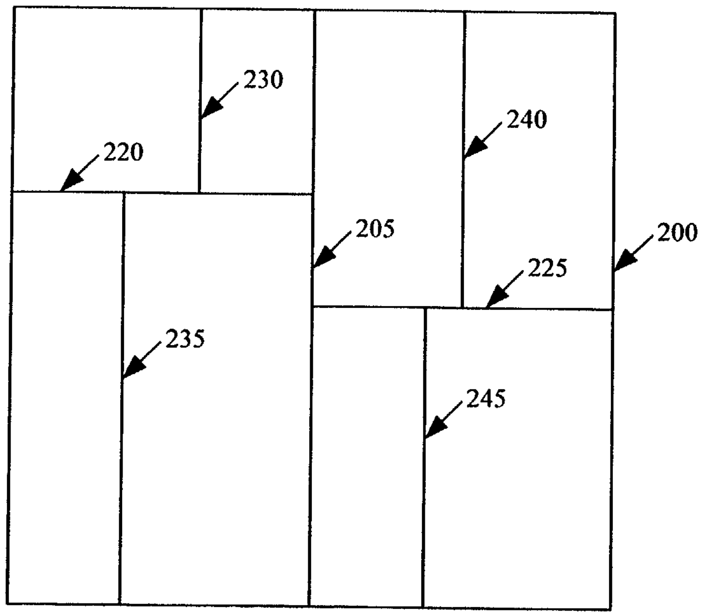


Figure 3

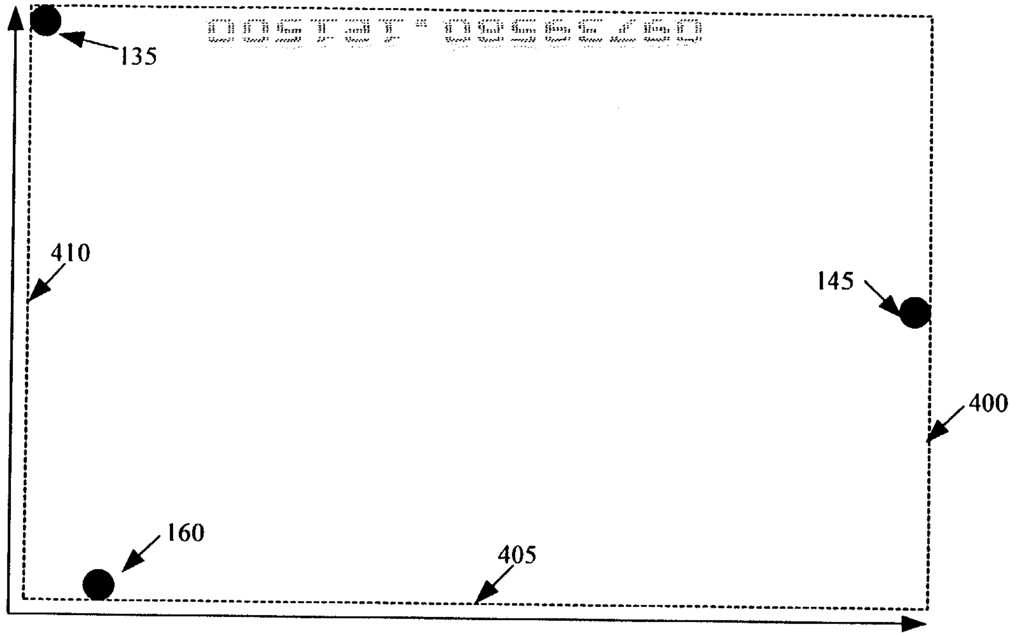


Figure 4

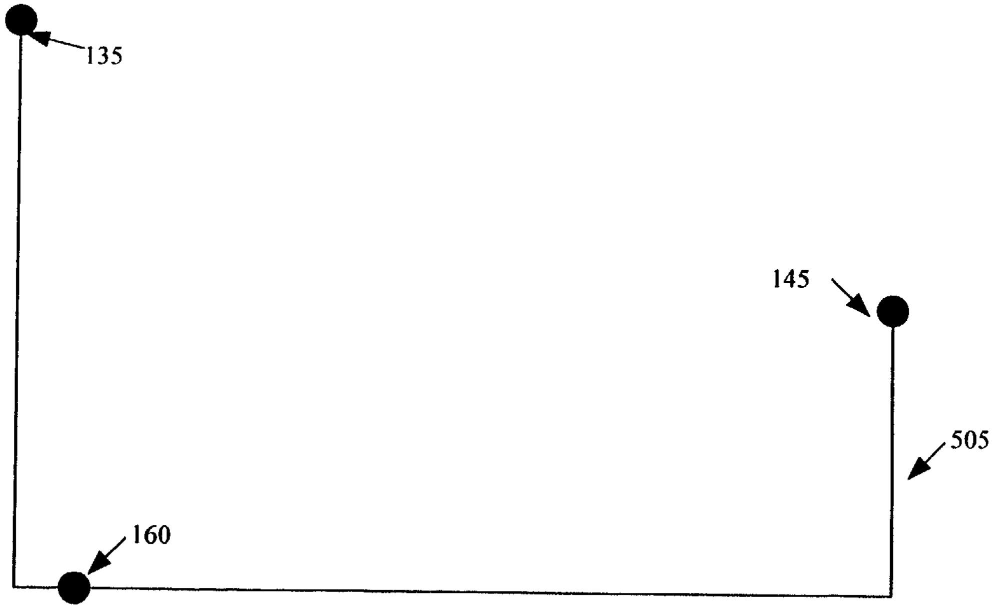


Figure 5

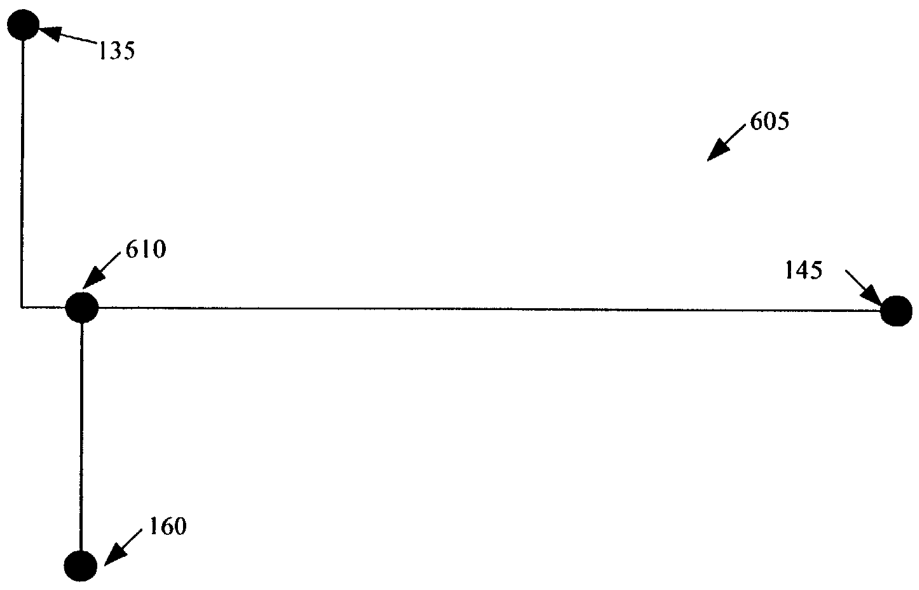


Figure 6

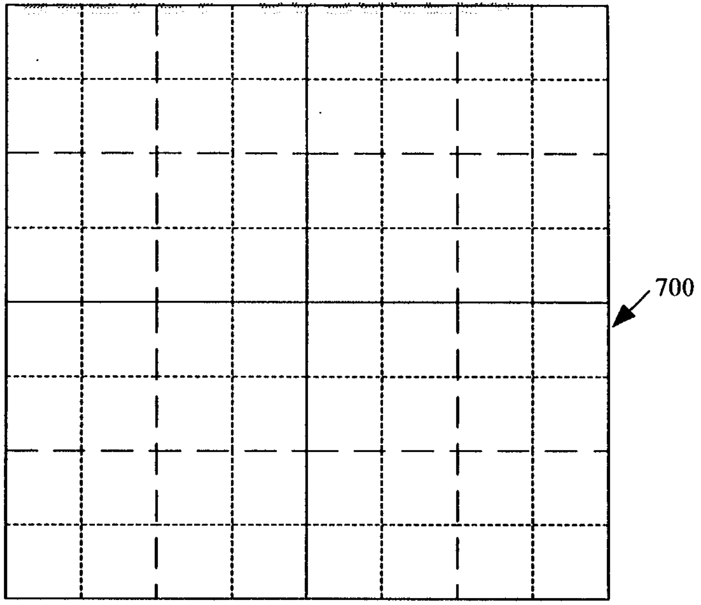


Figure 7

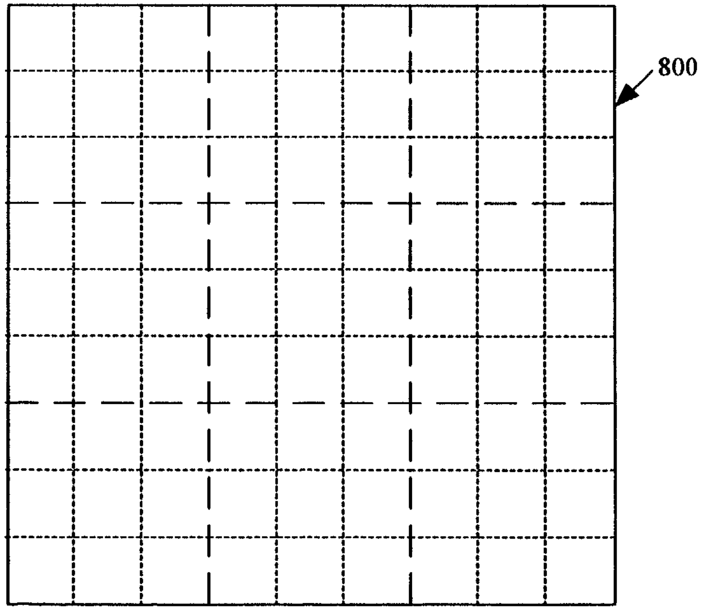


Figure 8

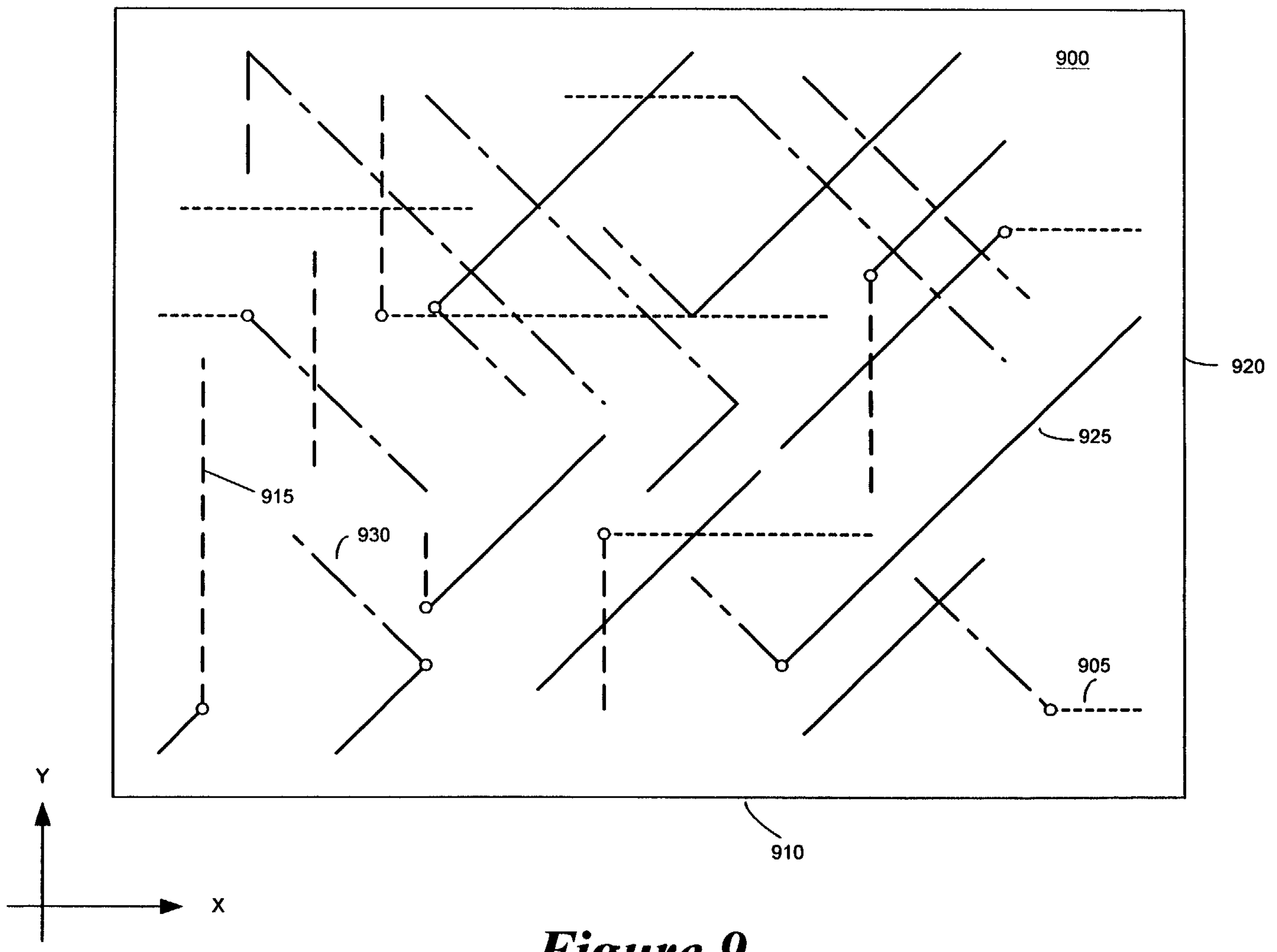


Figure 9

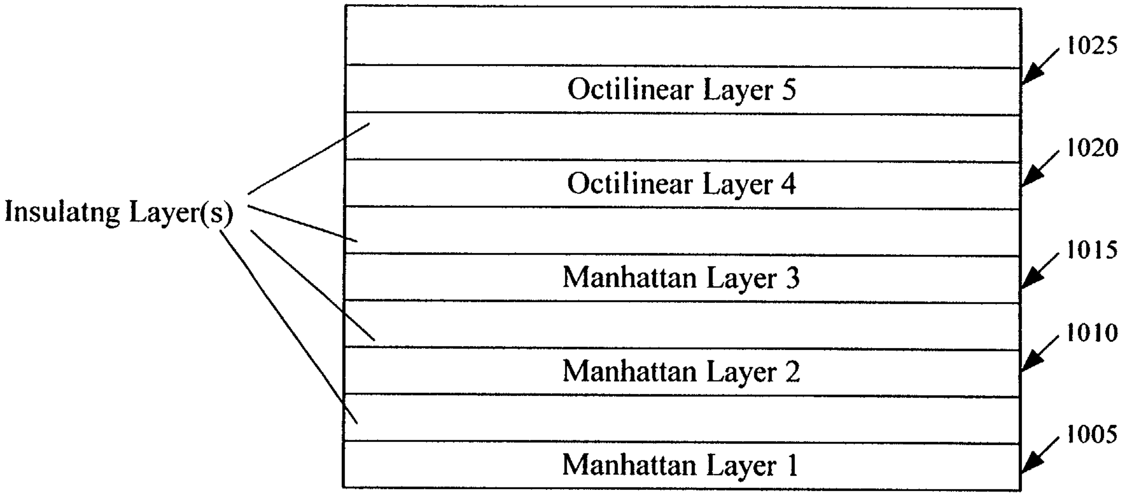

Insulatng Layer(s)
Octilinear Layer 5
Octilinear Layer 4
Manhattan Layer 3
Manhattan Layer 2
Manhattan Layer 1
1025
1020
1015
1010
1005

Figure 10

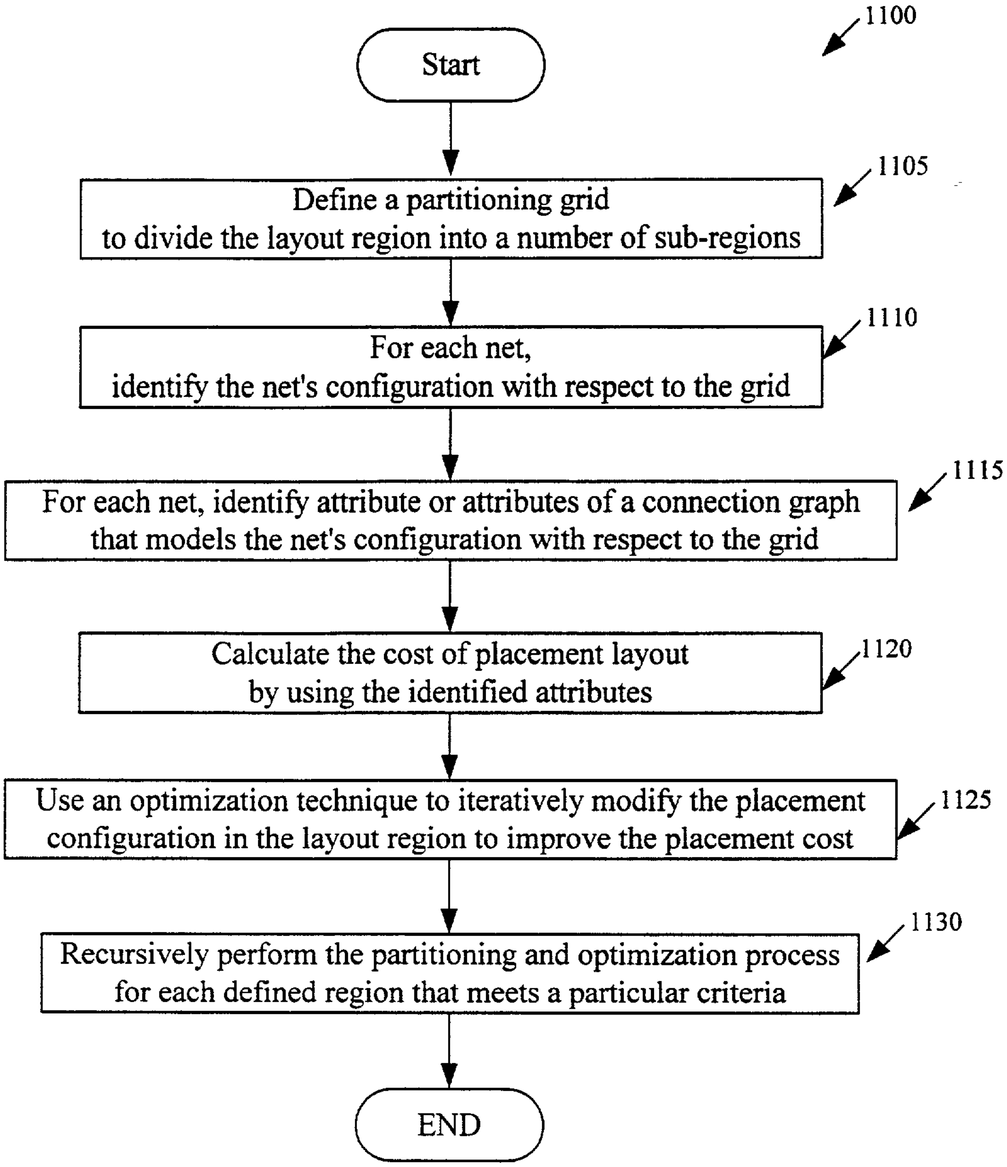

1100
Start
Define a partitioning grid
to divide the layout region into a number of sub-regions
1105
For each net,
identify the net's configuration with respect to the grid
1110
For each net, identify attribute or attributes of a connection graph
that models the net's configuration with respect to the grid
1115
Calculate the cost of placement layout
by using the identified attributes
1120
Use an optimization technique to iteratively modify the placement
configuration in the layout region to improve the placement cost
1125
Recursively perform the partitioning and optimization process
for each defined region that meets a particular criteria
1130
END

Figure 11

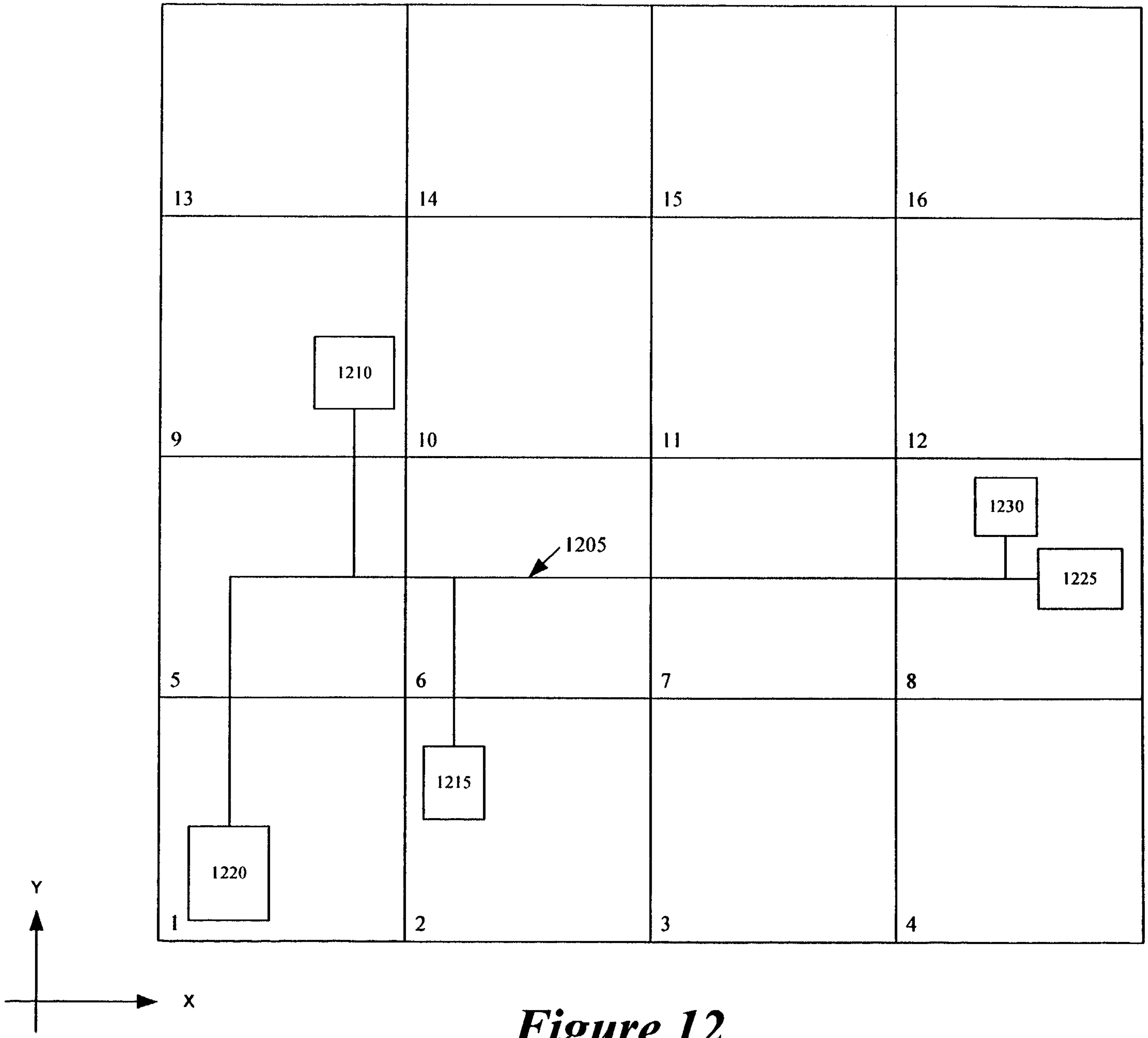


Figure 12

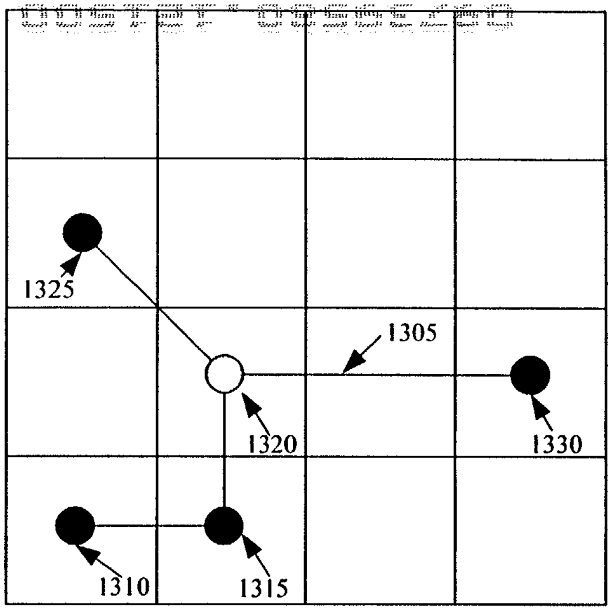


Figure 13

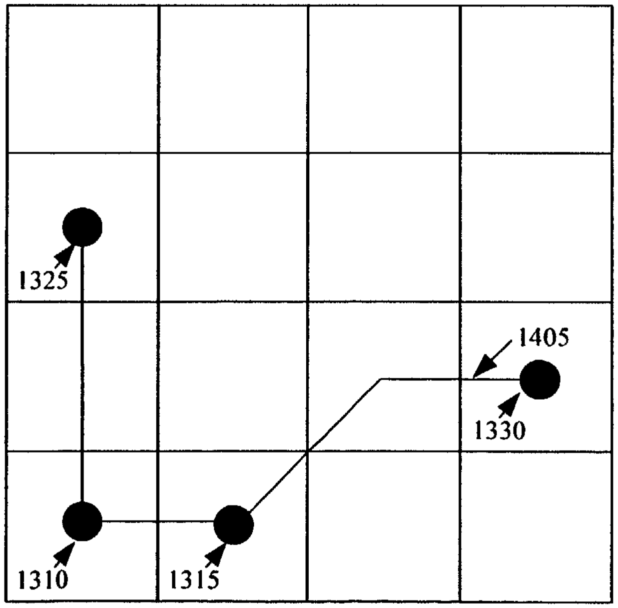


Figure 14

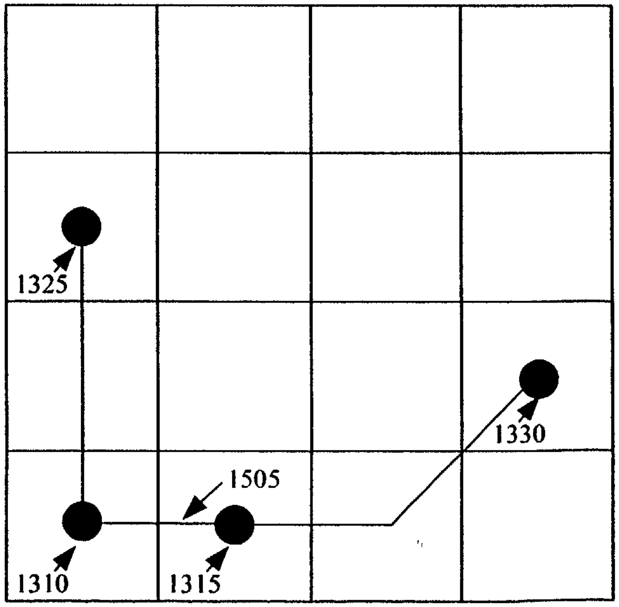


Figure 15

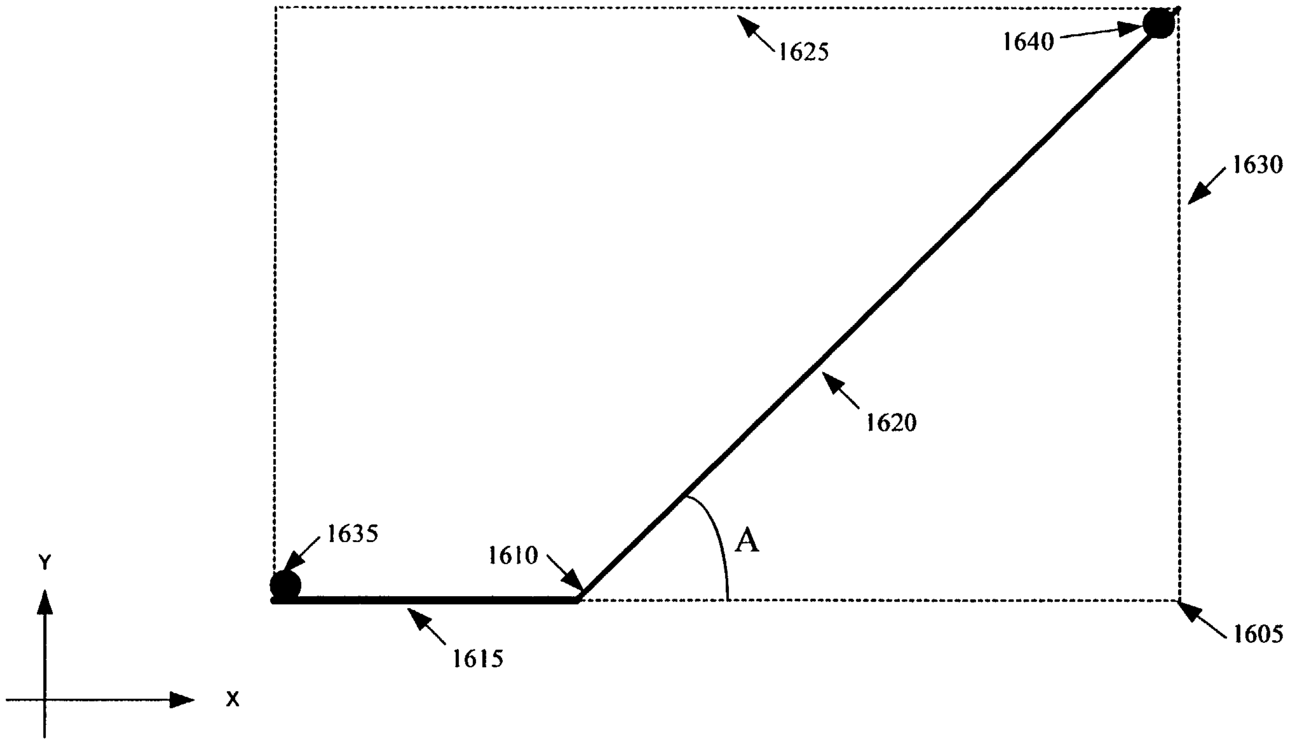


Figure 16

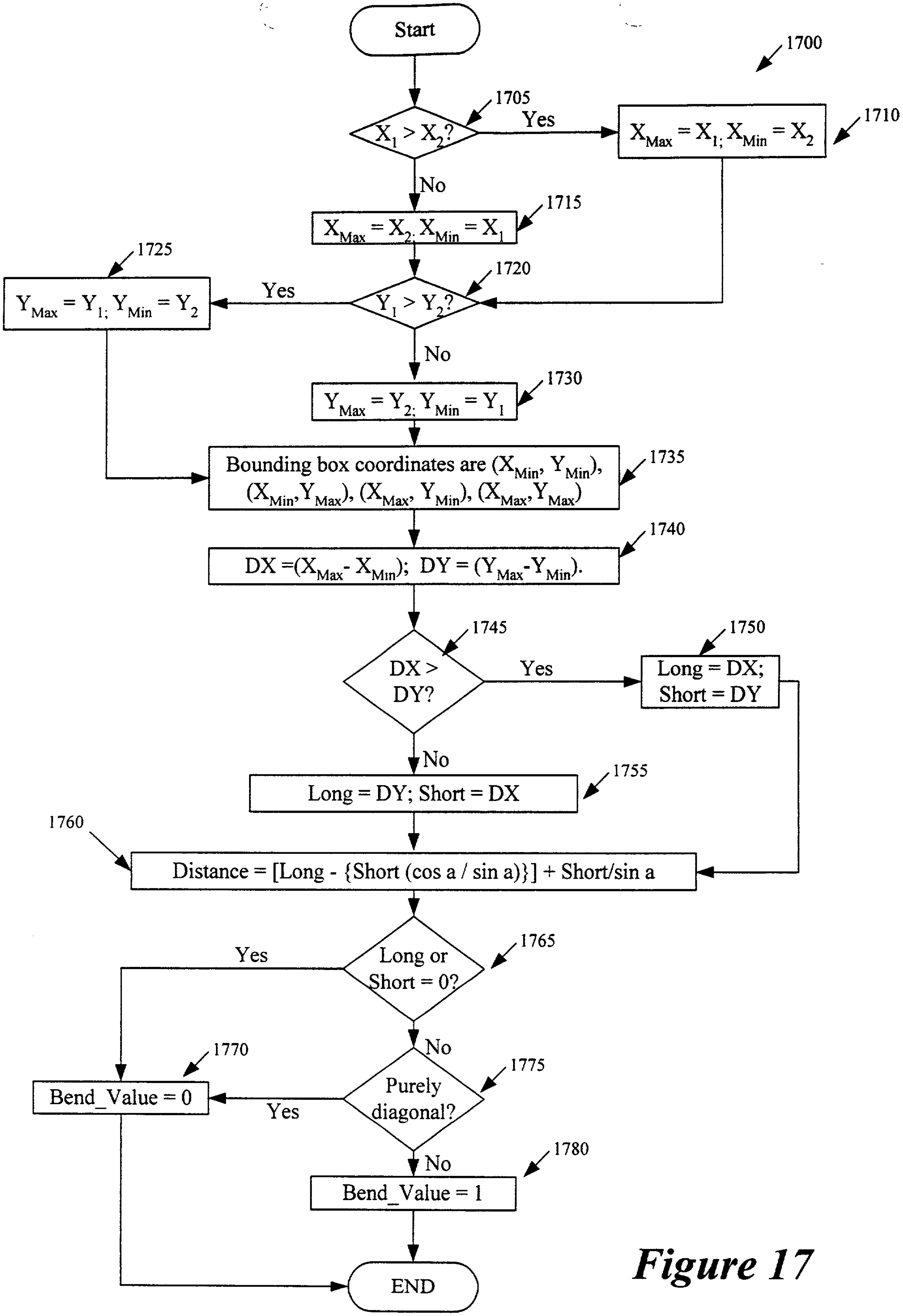

Start
1700
1705
X1 > X2?
Yes
XMax = X1; XMin = X2
1710
No
XMax = X2; XMin = X1
1715
1725
1720
YMax = Y1; YMin = Y2
Yes
Y1 > Y2?
No
YMax = Y2; YMin = Y1
1730
Bounding box coordinates are (XMin, YMin), (XMin,YMax), (XMax, YMin), (XMax,YMax)
1735
DX =(XMax- XMin); DY = (YMax-YMin).
1740
1745
1750
DX > DY?
Yes
Long = DX; Short = DY
No
Long = DY; Short = DX
1755
1760
Distance = [Long - {Short (cos a / sin a)}] + Short/sin a
Yes
Long or Short = 0?
1765
No
1770
1775
Bend_Value = 0
Yes
Purely diagonal?
No
1780
Bend_Value = 1
END

Figure 17

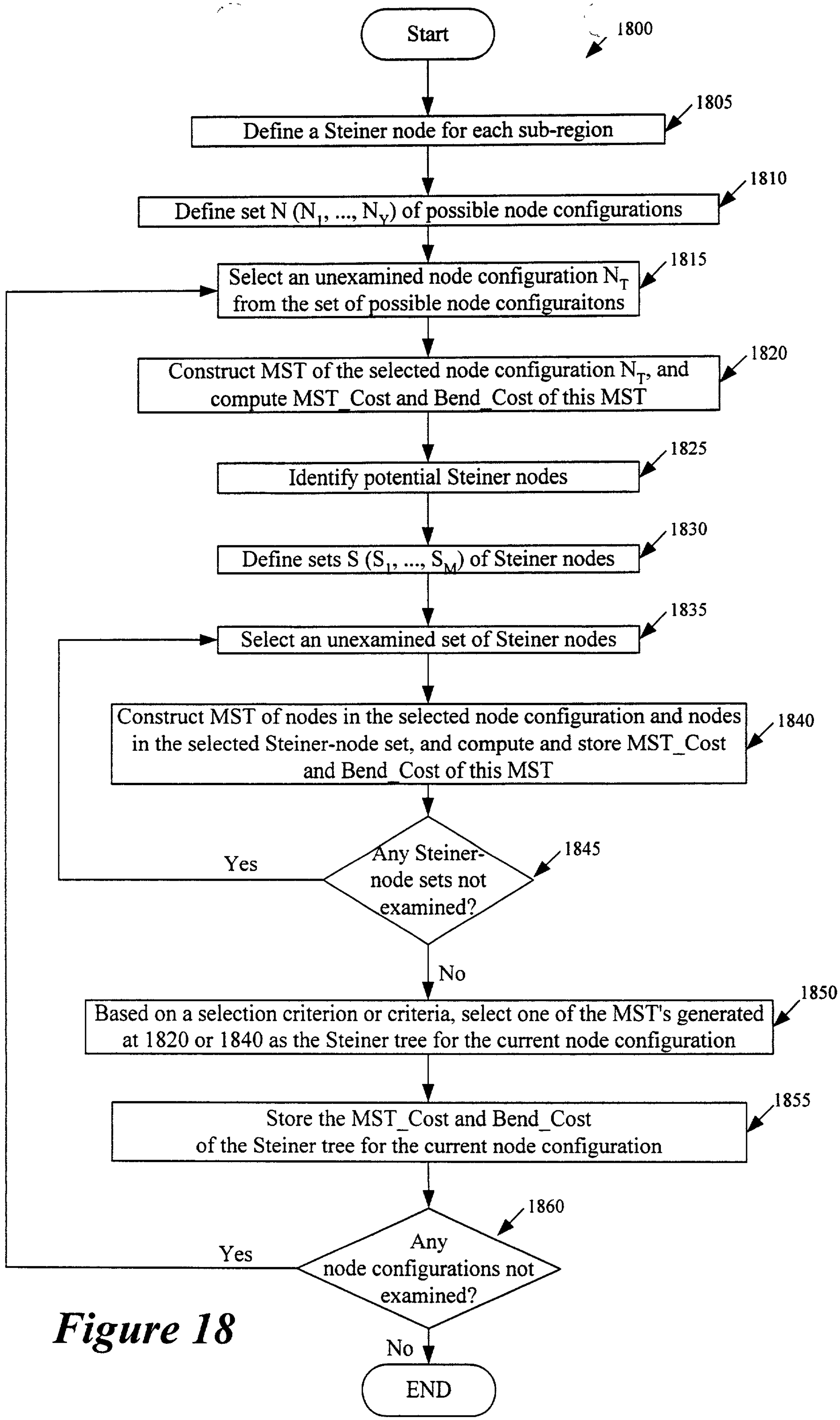

Start
1800
Define a Steiner node for each sub-region
1805
Define set N (N_1, ..., N_Y) of possible node configurations
1810
Select an unexamined node configuration N_T from the set of possible node configuraitons
1815
Construct MST of the selected node configuration N_T, and compute MST_Cost and Bend_Cost of this MST
1820
Identify potential Steiner nodes
1825
Define sets S (S_1, ..., S_M) of Steiner nodes
1830
Select an unexamined set of Steiner nodes
1835
Construct MST of nodes in the selected node configuration and nodes in the selected Steiner-node set, and compute and store MST_Cost and Bend_Cost of this MST
1840
Any Steiner-node sets not examined?
1845
Yes
No
Based on a selection criterion or criteria, select one of the MST's generated at 1820 or 1840 as the Steiner tree for the current node configuration
1850
Store the MST_Cost and Bend_Cost of the Steiner tree for the current node configuration
1855
Any node configurations not examined?
1860
Yes
No
END

Figure 18

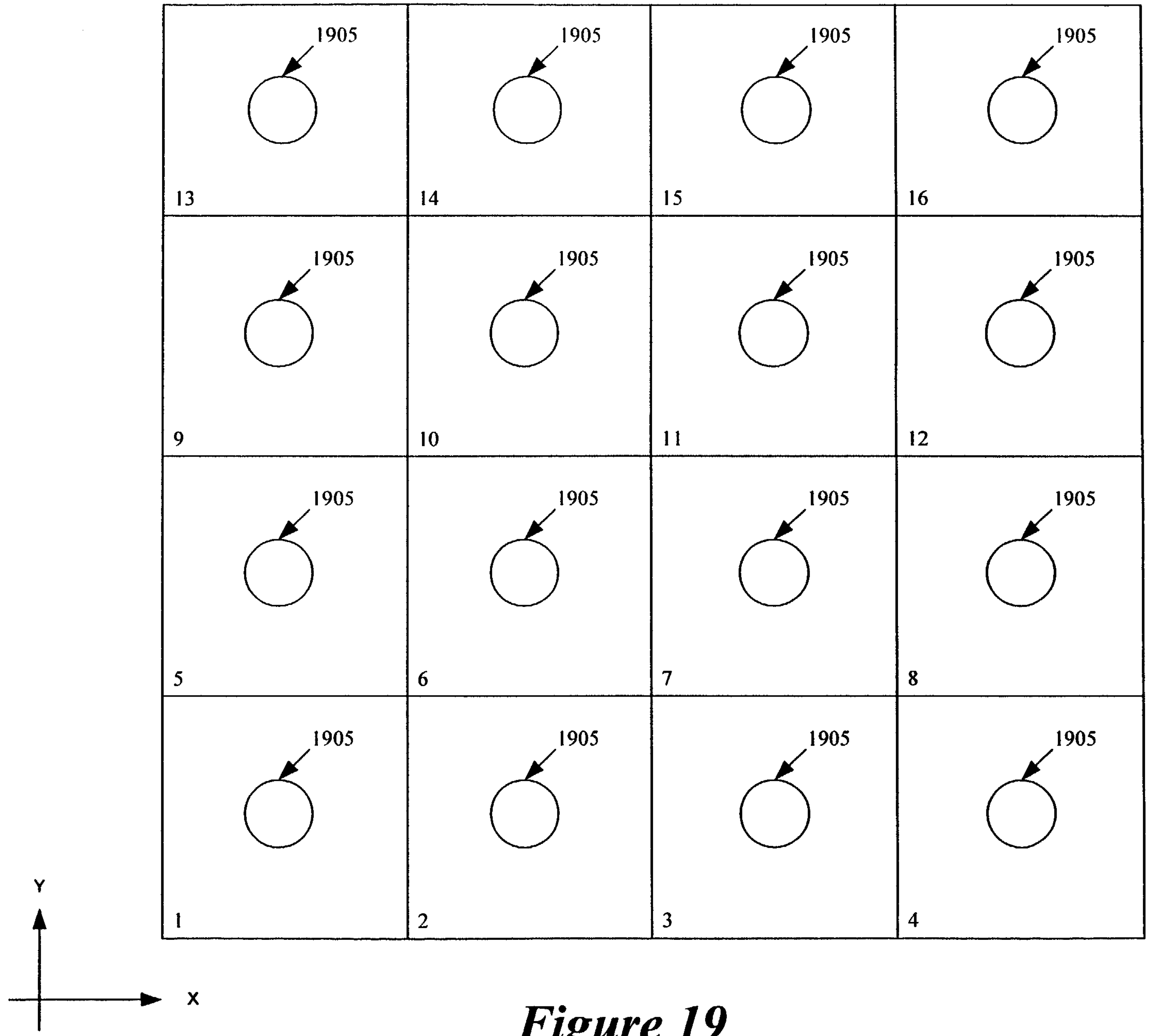


Figure 19

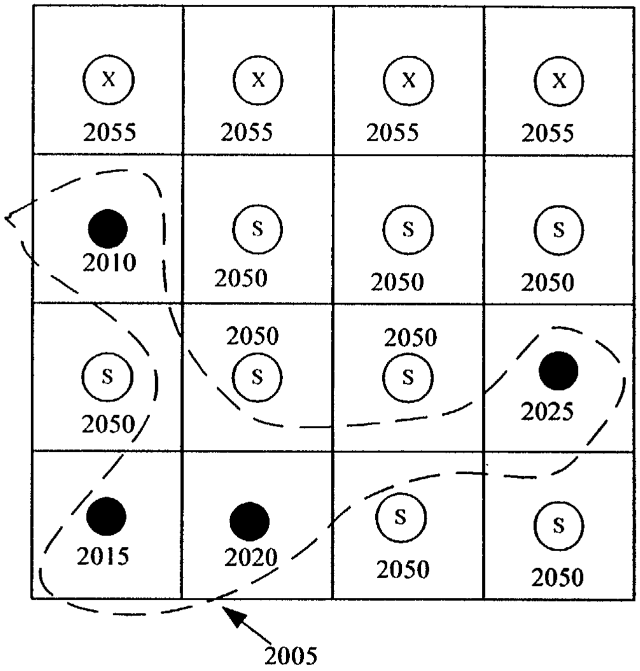

X
2055
X
2055
X
2055
X
2055
2010
S
2050
S
2050
S
2050
S
2050
2050
S
2050
S
2025
2015
2020
S
2050
S
2050
2005

Figure 20

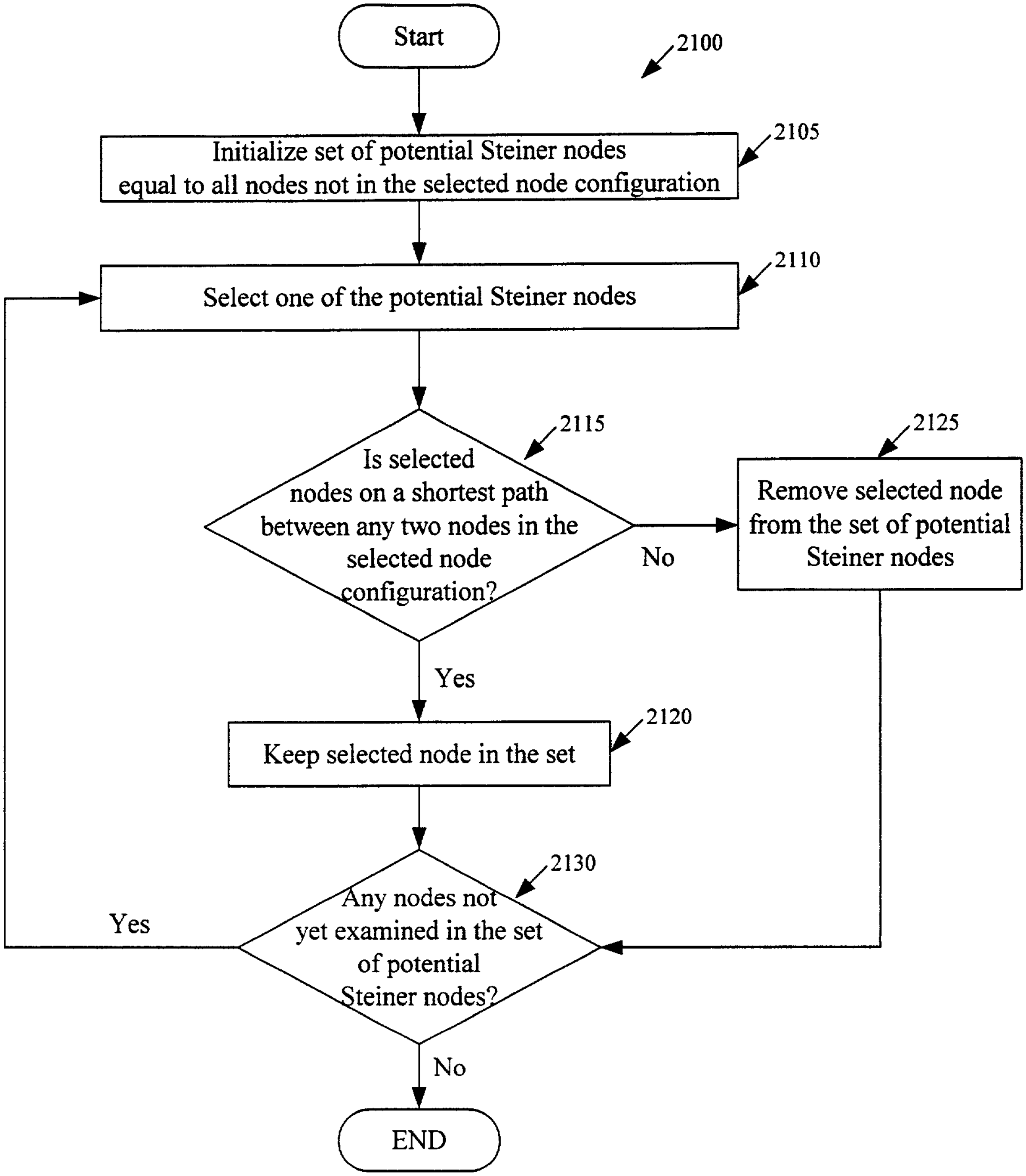

Start
2100
Initialize set of potential Steiner nodes equal to all nodes not in the selected node configuration
2105
Select one of the potential Steiner nodes
2110
Is selected nodes on a shortest path between any two nodes in the selected node configuration?
2115
No
Remove selected node from the set of potential Steiner nodes
2125
Yes
Keep selected node in the set
2120
Any nodes not yet examined in the set of potential Steiner nodes?
2130
Yes
No
END

Figure 21

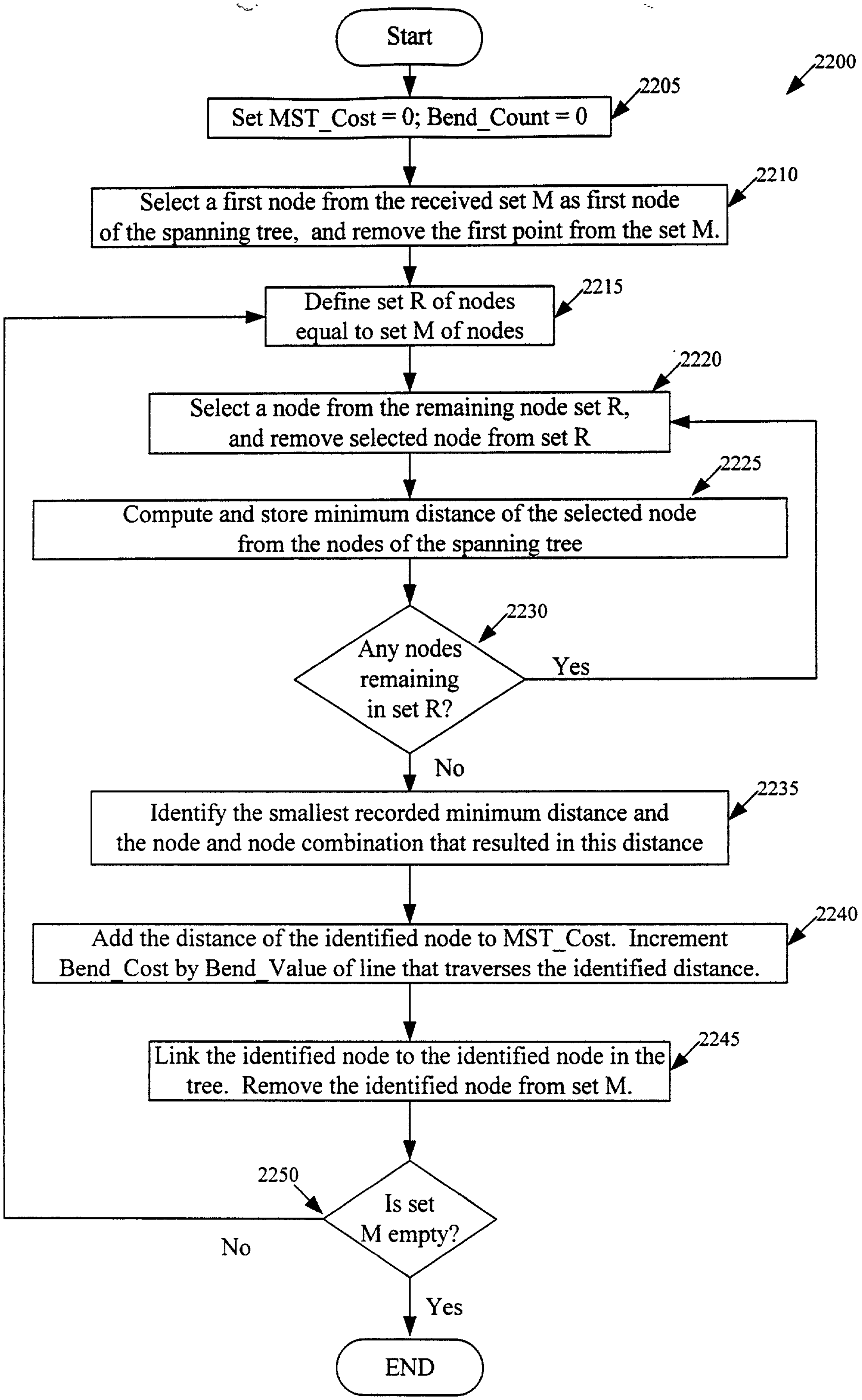

Start
2200
2205
Set MST_Cost = 0; Bend_Count = 0
2210
Select a first node from the received set M as first node of the spanning tree, and remove the first point from the set M.
2215
Define set R of nodes equal to set M of nodes
2220
Select a node from the remaining node set R, and remove selected node from set R
2225
Compute and store minimum distance of the selected node from the nodes of the spanning tree
2230
Any nodes remaining in set R?
Yes
No
2235
Identify the smallest recorded minimum distance and the node and node combination that resulted in this distance
2240
Add the distance of the identified node to MST_Cost. Increment Bend_Cost by Bend_Value of line that traverses the identified distance.
2245
Link the identified node to the identified node in the tree. Remove the identified node from set M.
2250
Is set M empty?
No
Yes
END

Figure 22

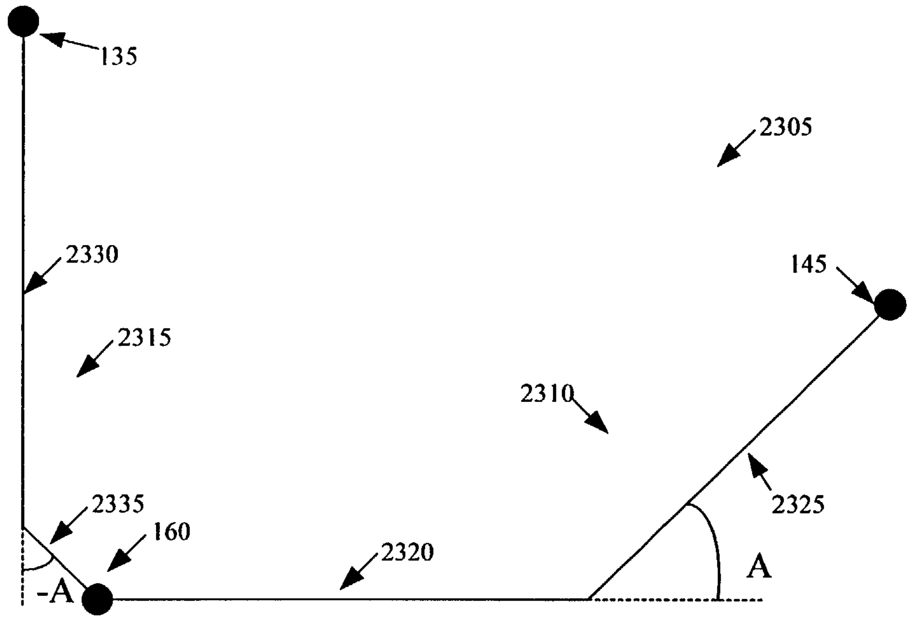


Figure 23

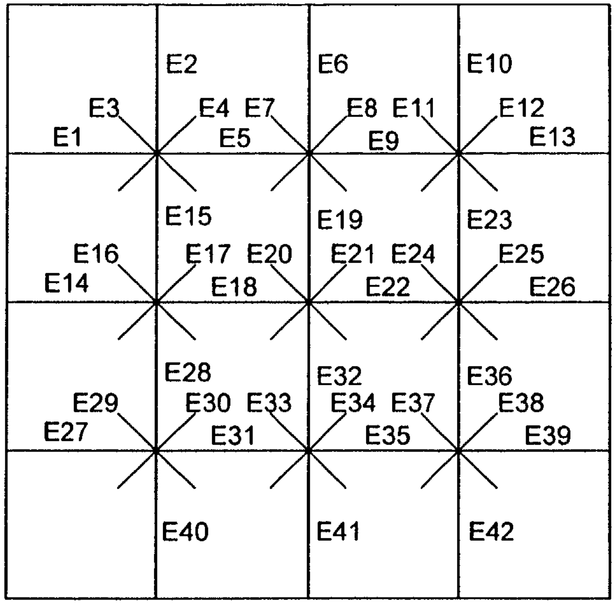


Figure 24

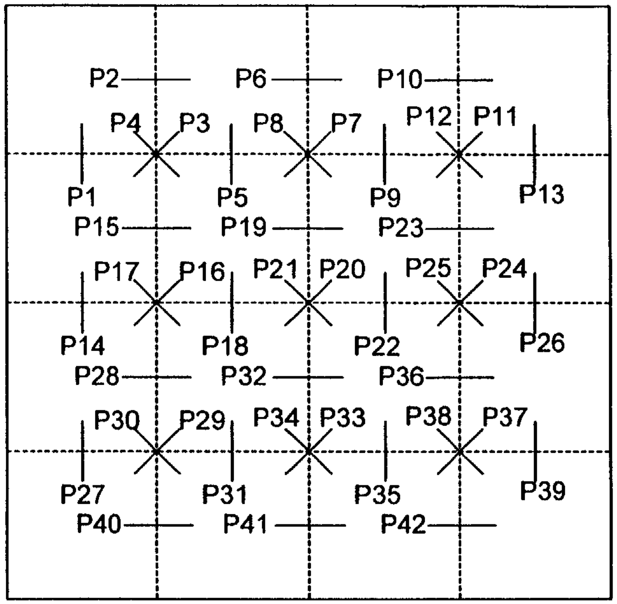


Figure 25

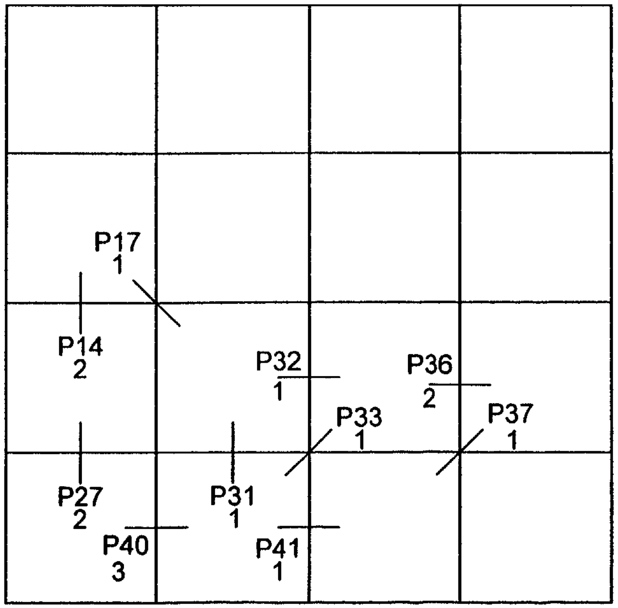


Figure 26

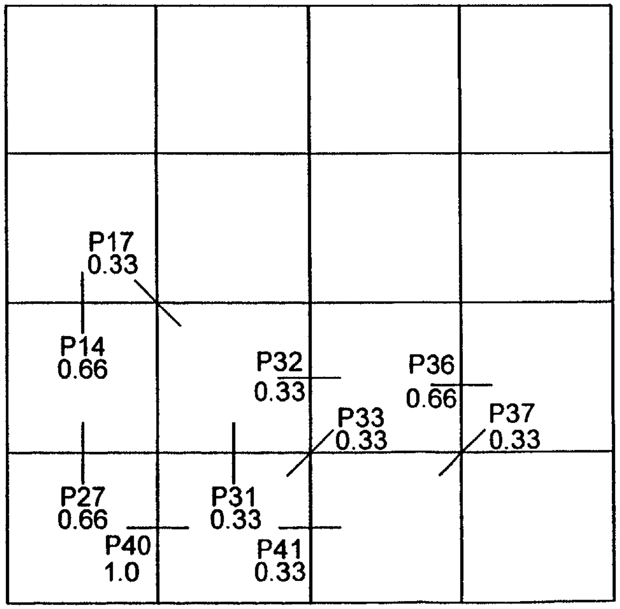


Figure 27

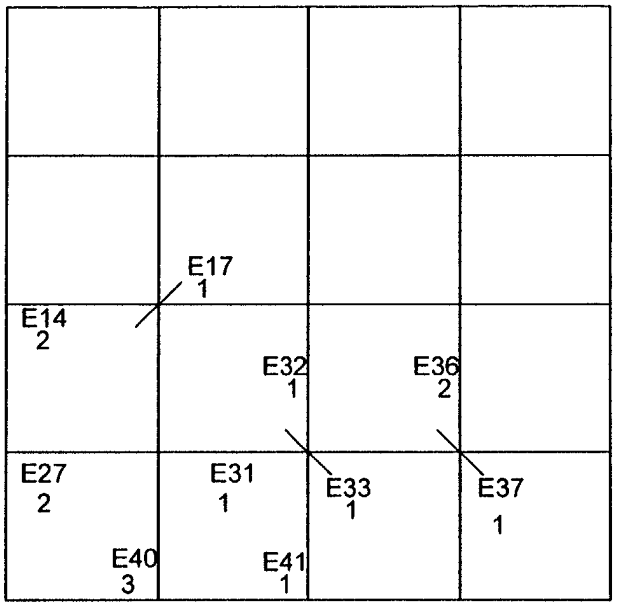


Figure 28

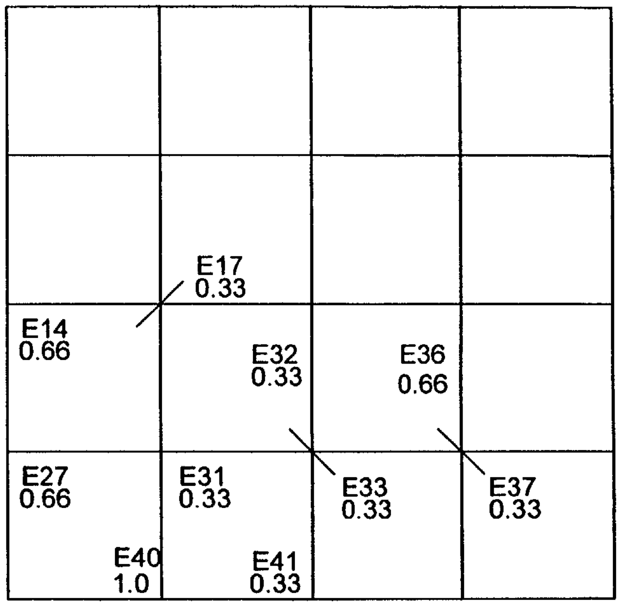
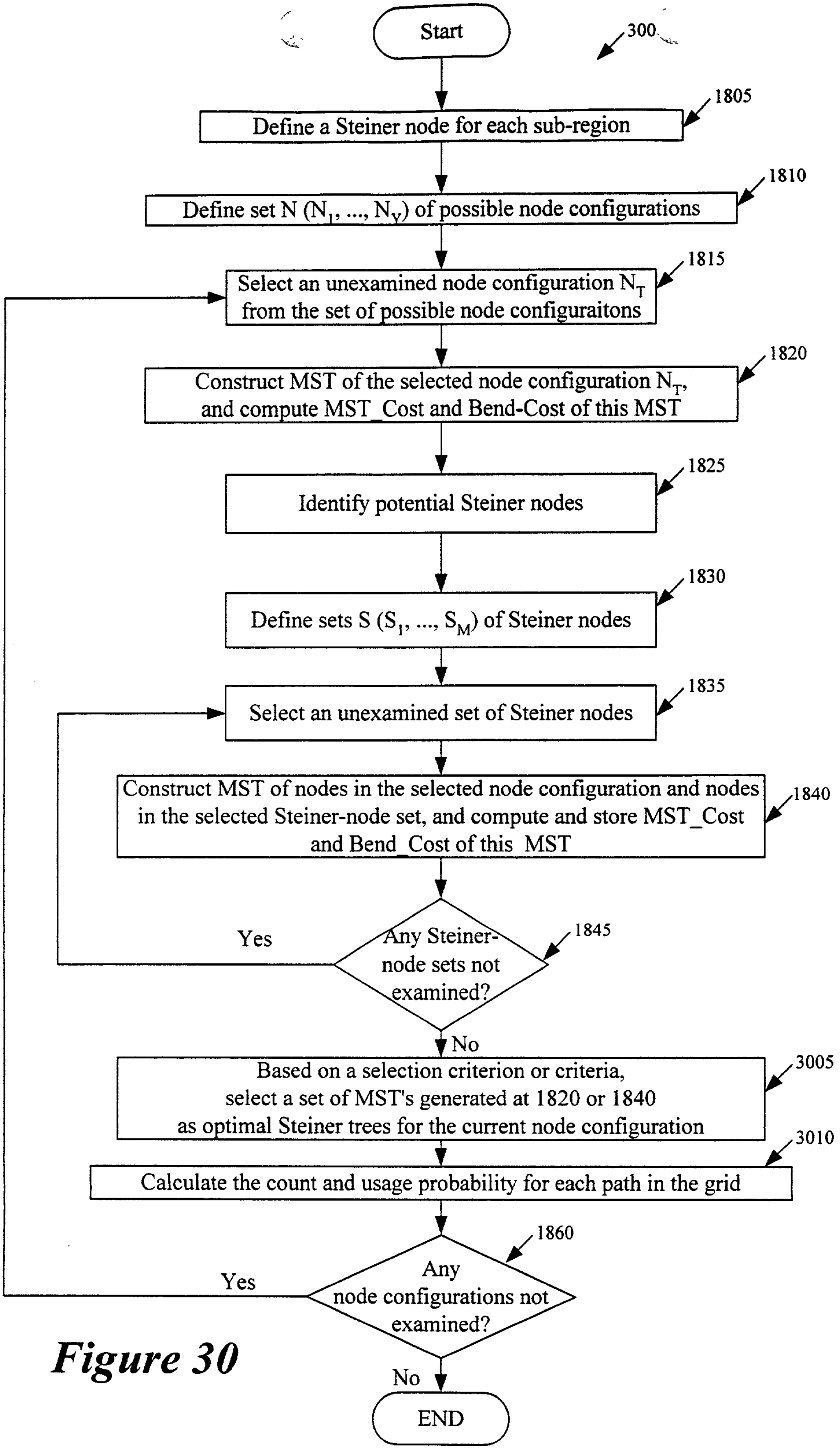


Figure 29



Start
300
Define a Steiner node for each sub-region
1805
Define set N (N_1, ..., N_Y) of possible node configurations
1810
Select an unexamined node configuration N_T from the set of possible node configuraitons
1815
Construct MST of the selected node configuration N_T, and compute MST_Cost and Bend-Cost of this MST
1820
Identify potential Steiner nodes
1825
Define sets S (S_1, ..., S_M) of Steiner nodes
1830
Select an unexamined set of Steiner nodes
1835
Construct MST of nodes in the selected node configuration and nodes in the selected Steiner-node set, and compute and store MST_Cost and Bend_Cost of this MST
1840
Yes
Any Steiner-node sets not examined?
1845
No
Based on a selection criterion or criteria, select a set of MST's generated at 1820 or 1840 as optimal Steiner trees for the current node configuration
3005
Calculate the count and usage probability for each path in the grid
3010
Yes
Any node configurations not examined?
1860
No
END

Figure 30

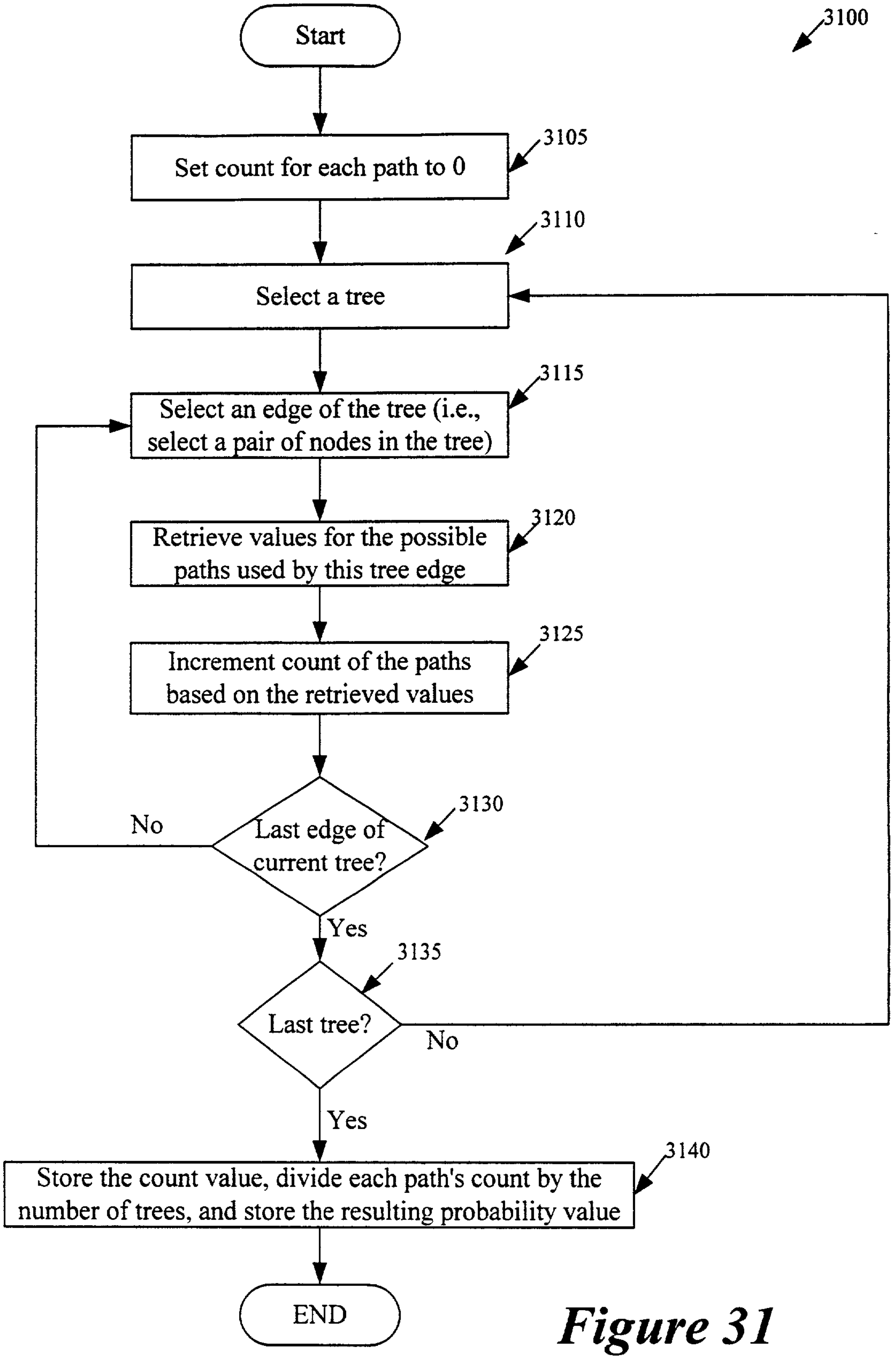

Start
3100
Set count for each path to 0
3105
3110
Select a tree
Select an edge of the tree (i.e., select a pair of nodes in the tree)
3115
Retrieve values for the possible paths used by this tree edge
3120
Increment count of the paths based on the retrieved values
3125
Last edge of current tree?
3130
No
Yes
Last tree?
3135
No
Yes
Store the count value, divide each path's count by the number of trees, and store the resulting probability value
3140
END

Figure 31

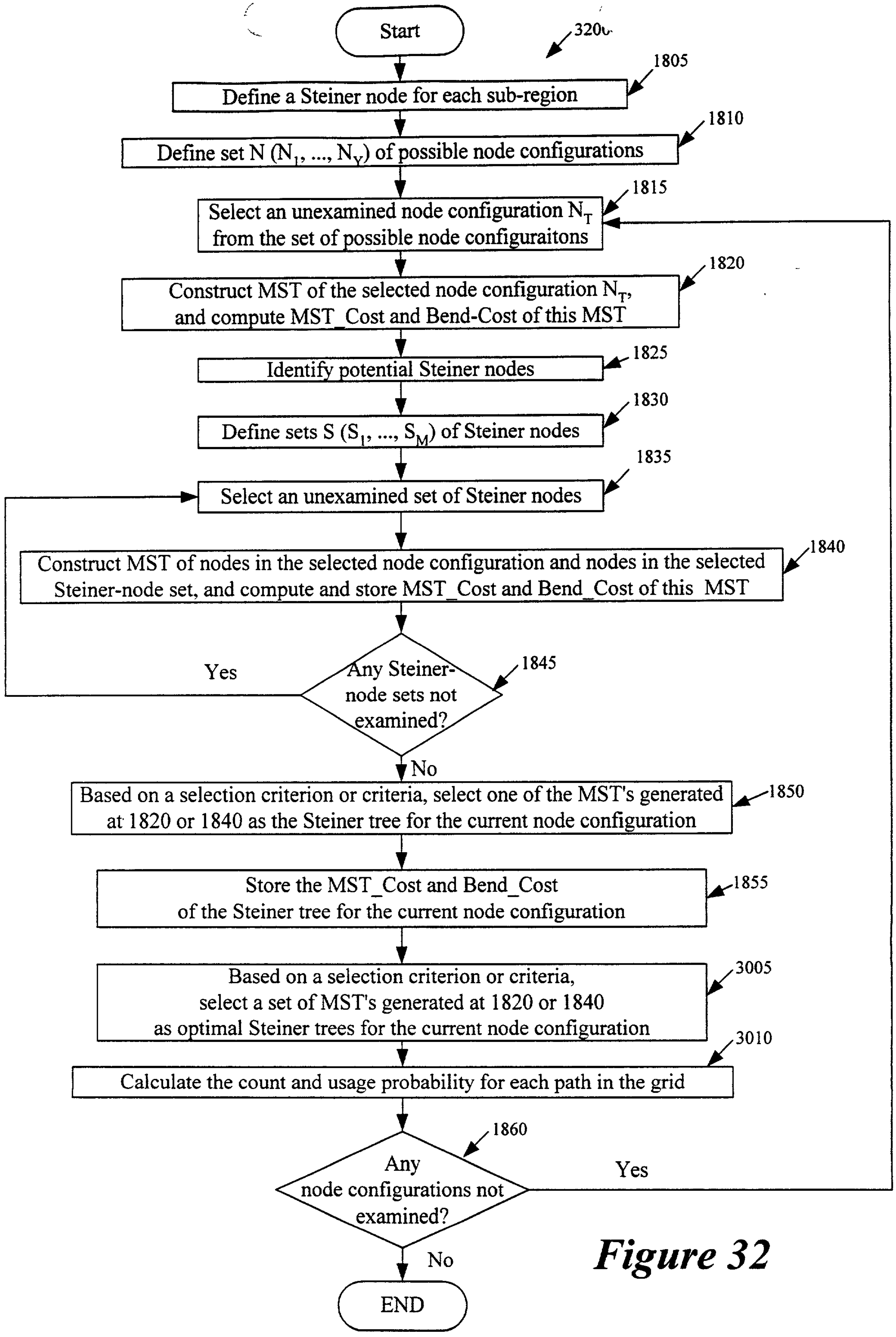

Start
3200
1805
Define a Steiner node for each sub-region
1810
Define set N (N_1, ..., N_Y) of possible node configurations
1815
Select an unexamined node configuration N_T from the set of possible node configuraitons
1820
Construct MST of the selected node configuration N_T, and compute MST_Cost and Bend-Cost of this MST
1825
Identify potential Steiner nodes
1830
Define sets S (S_1, ..., S_M) of Steiner nodes
1835
Select an unexamined set of Steiner nodes
1840
Construct MST of nodes in the selected node configuration and nodes in the selected Steiner-node set, and compute and store MST_Cost and Bend_Cost of this MST
1845
Any Steiner-node sets not examined?
Yes
No
1850
Based on a selection criterion or criteria, select one of the MST's generated at 1820 or 1840 as the Steiner tree for the current node configuration
1855
Store the MST_Cost and Bend_Cost of the Steiner tree for the current node configuration
3005
Based on a selection criterion or criteria, select a set of MST's generated at 1820 or 1840 as optimal Steiner trees for the current node configuration
3010
Calculate the count and usage probability for each path in the grid
1860
Any node configurations not examined?
Yes
No
END

Figure 32

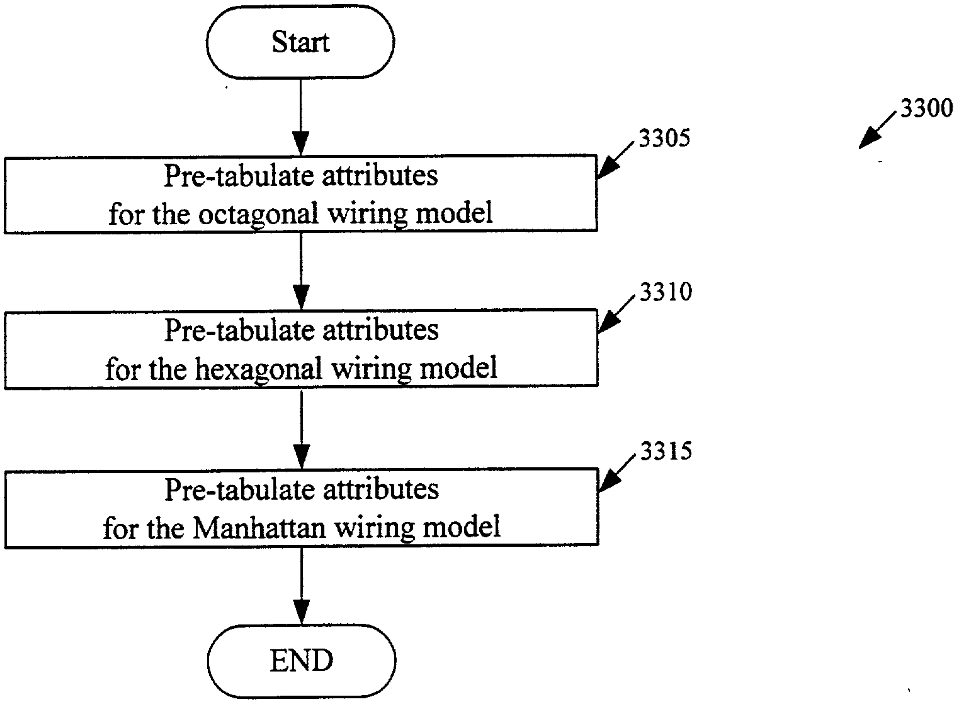

Start
3300
3305
Pre-tabulate attributes for the octagonal wiring model
3310
Pre-tabulate attributes for the hexagonal wiring model
3315
Pre-tabulate attributes for the Manhattan wiring model
END

Figure 33

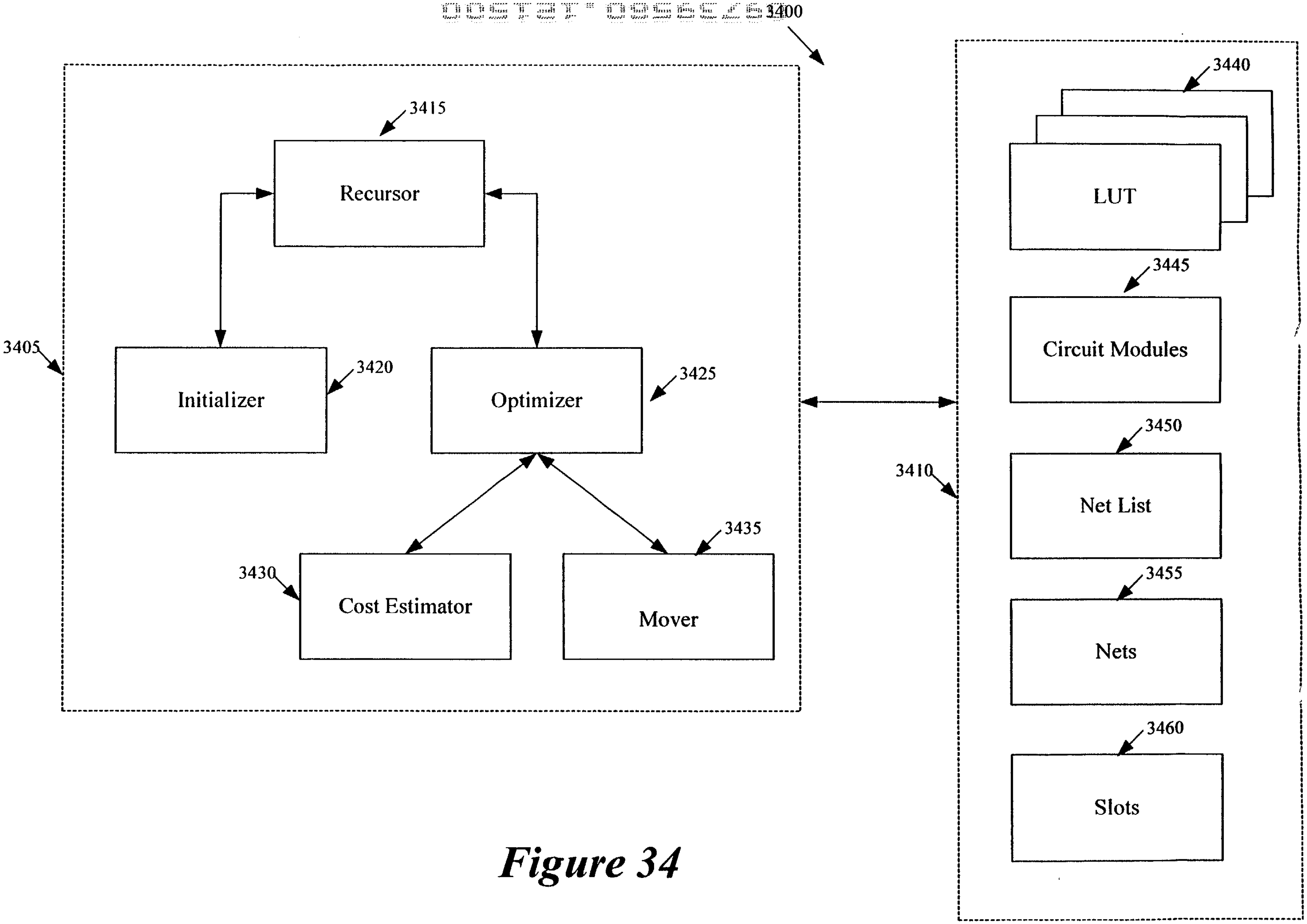

3400
3405
3415
Recursor
Initializer
3420
Optimizer
3425
3430
Cost Estimator
Mover
3435
3410
3440
LUT
3445
Circuit Modules
3450
Net List
3455
Nets
3460
Slots

Figure 34

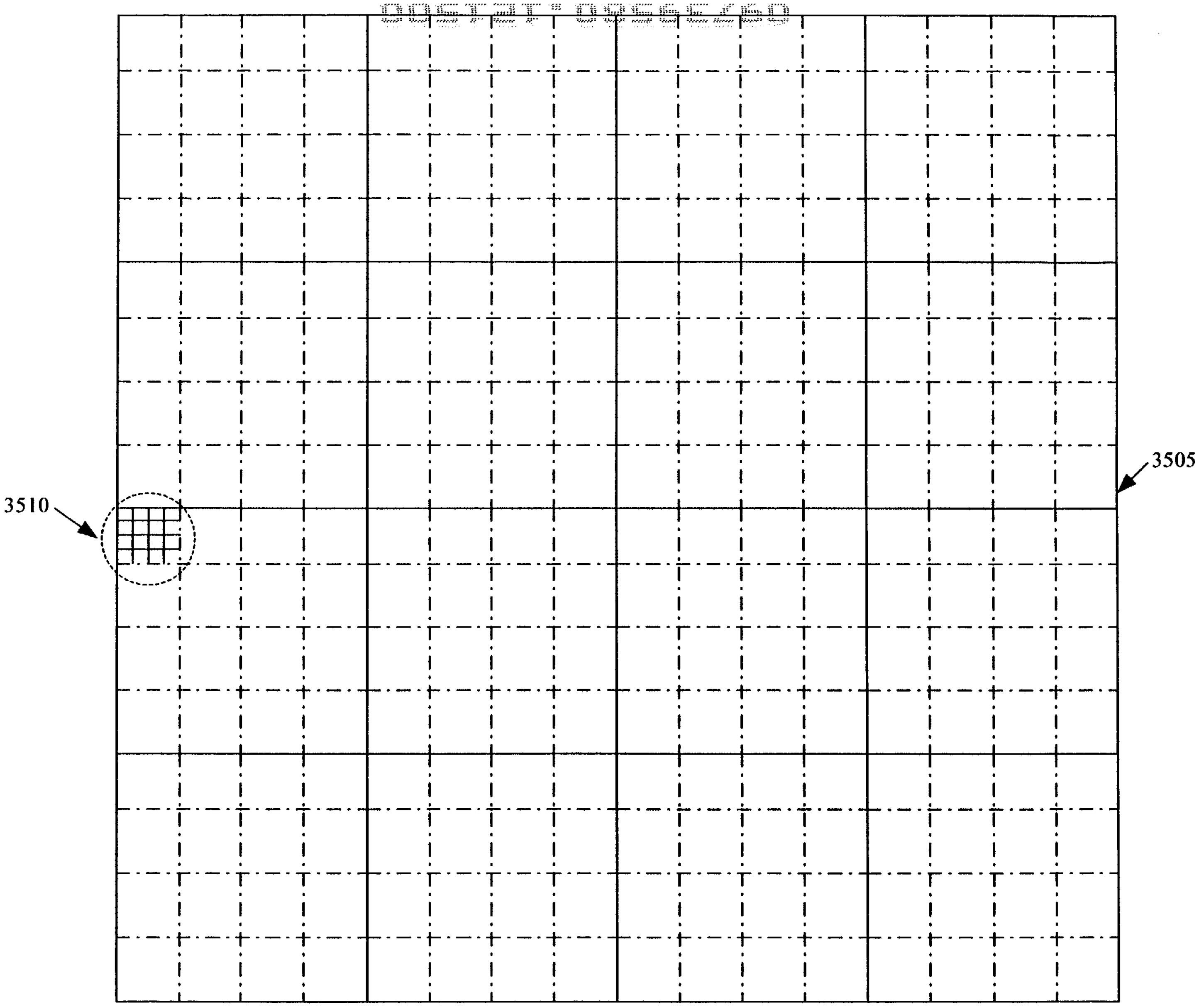


Figure 35

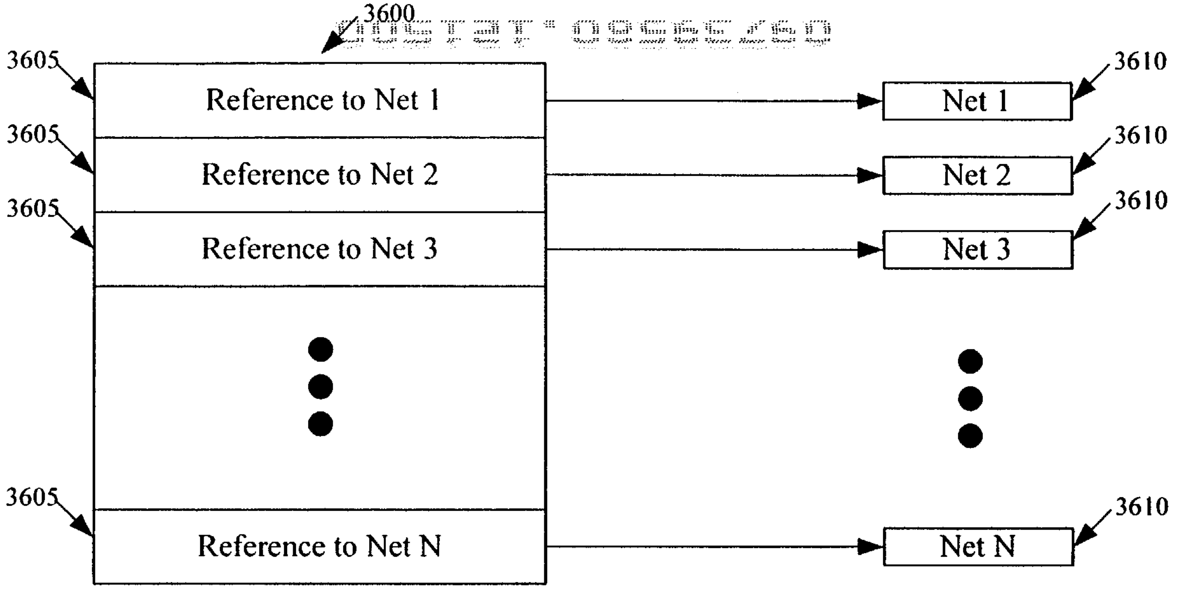


Figure 36

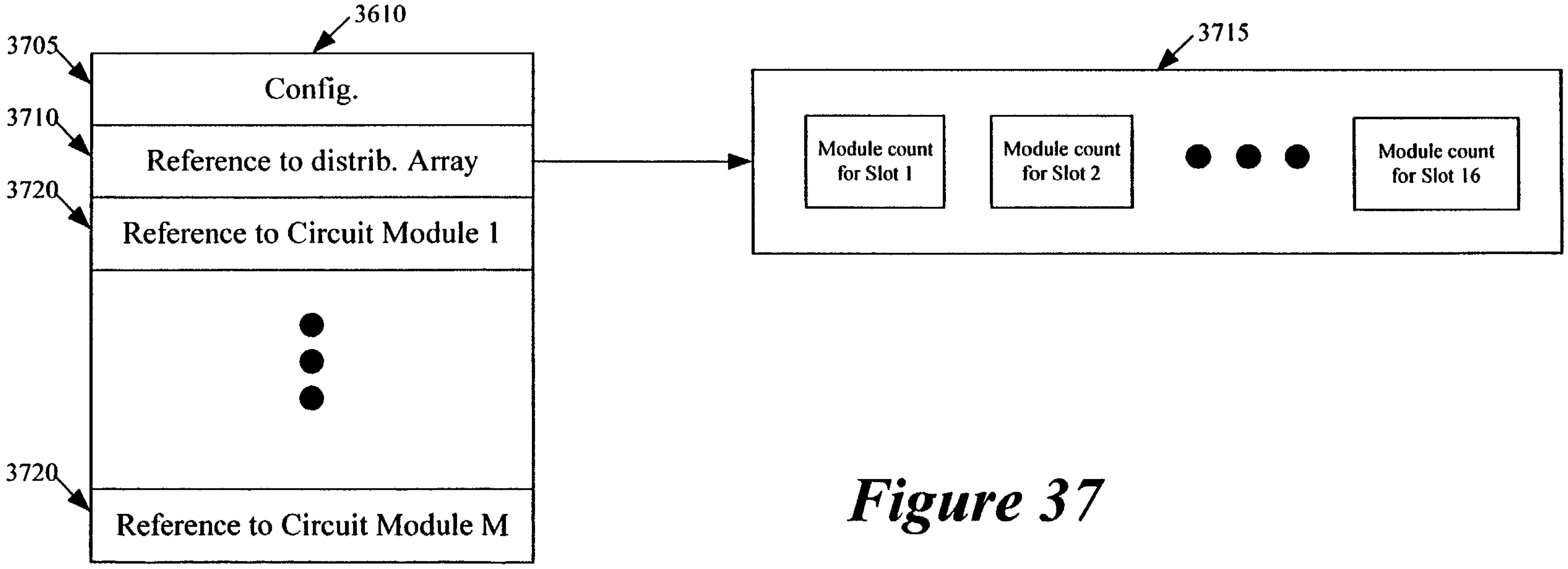


Figure 37

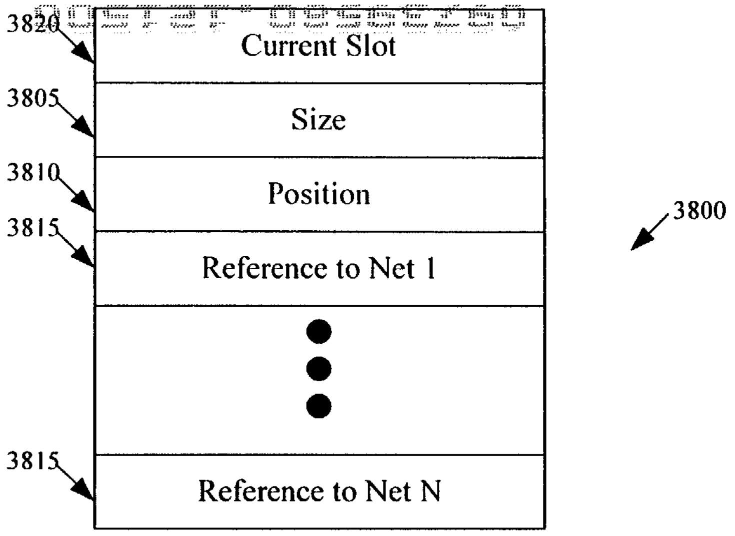


Figure 38

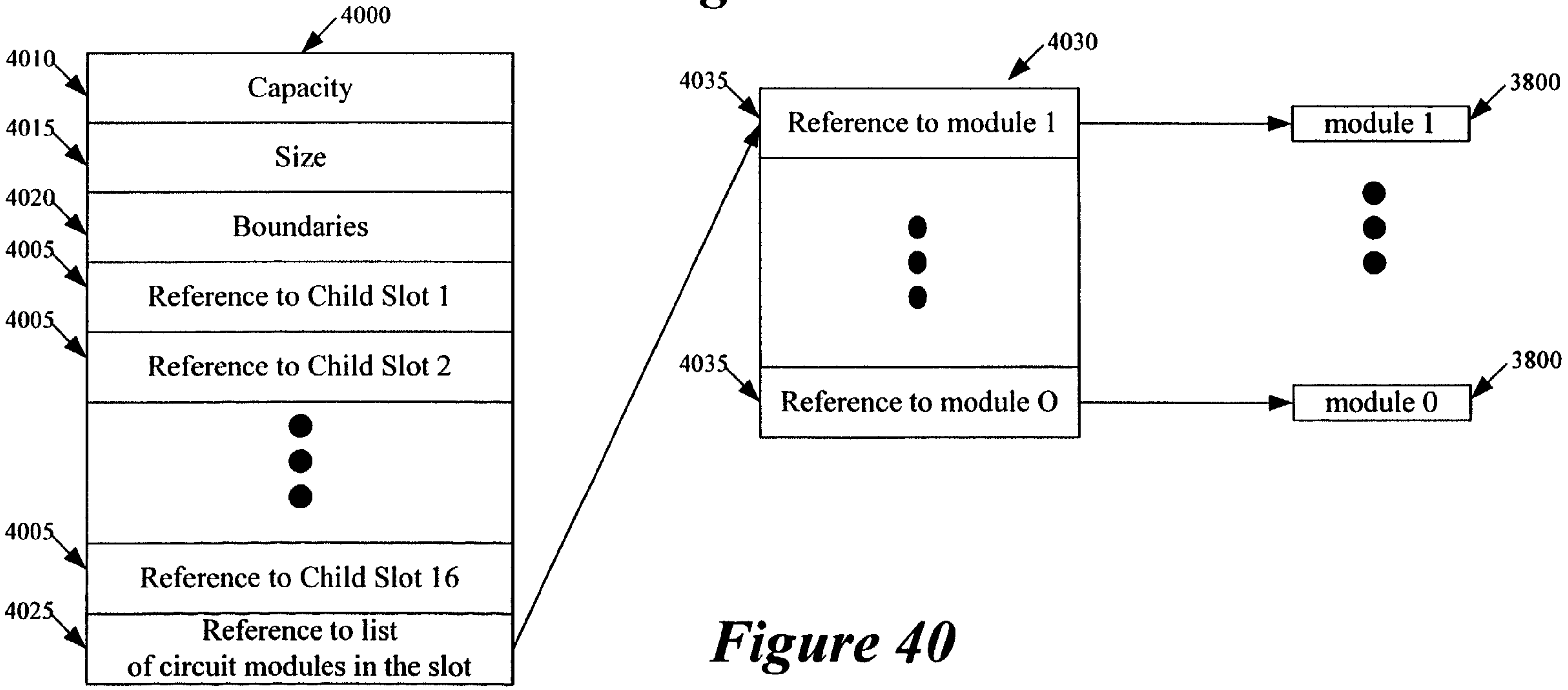


Figure 40

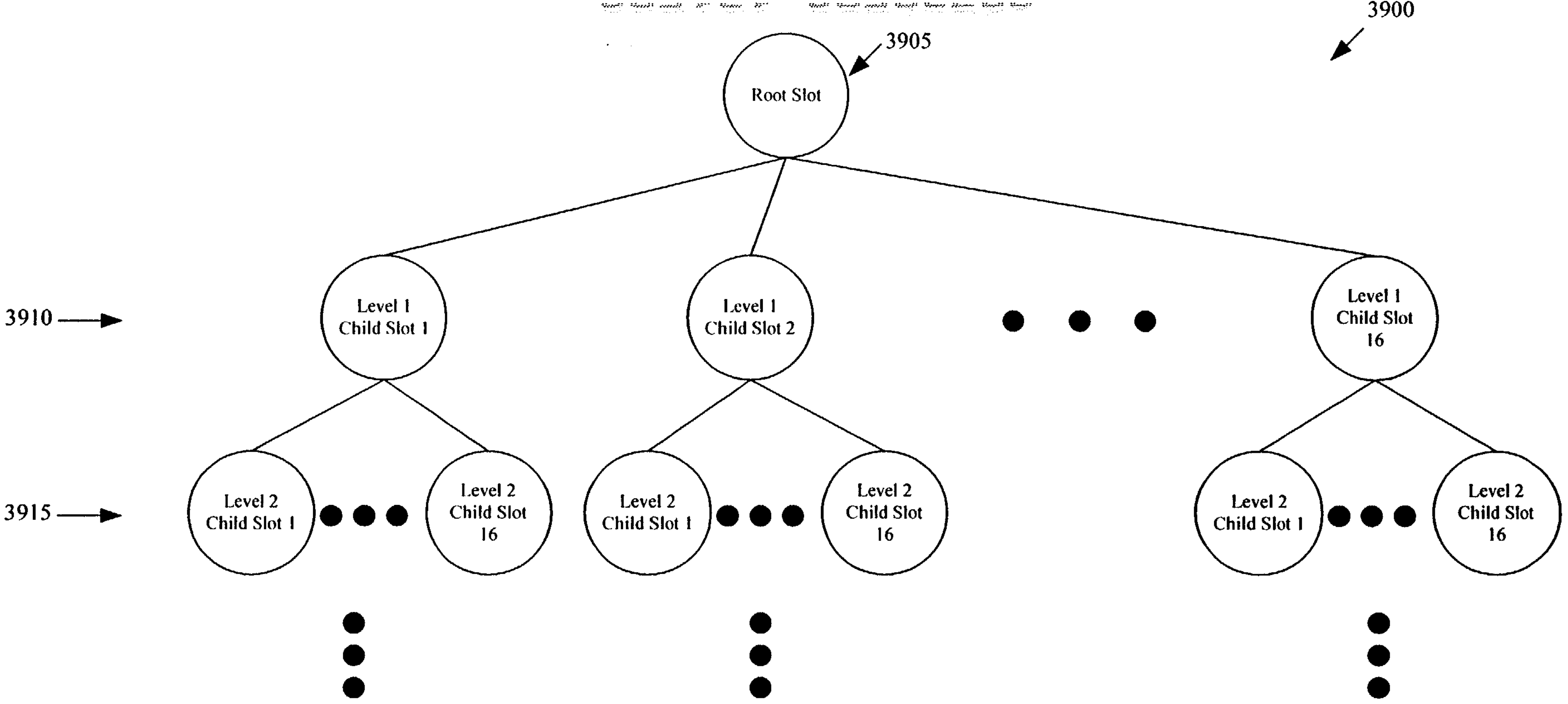

3900
3905
Root Slot
3910
Level 1 Child Slot 1
Level 1 Child Slot 2
Level 1 Child Slot 16
3915
Level 2 Child Slot 1
Level 2 Child Slot 16
Level 2 Child Slot 1
Level 2 Child Slot 16
Level 2 Child Slot 1
Level 2 Child Slot 16

Figure 39

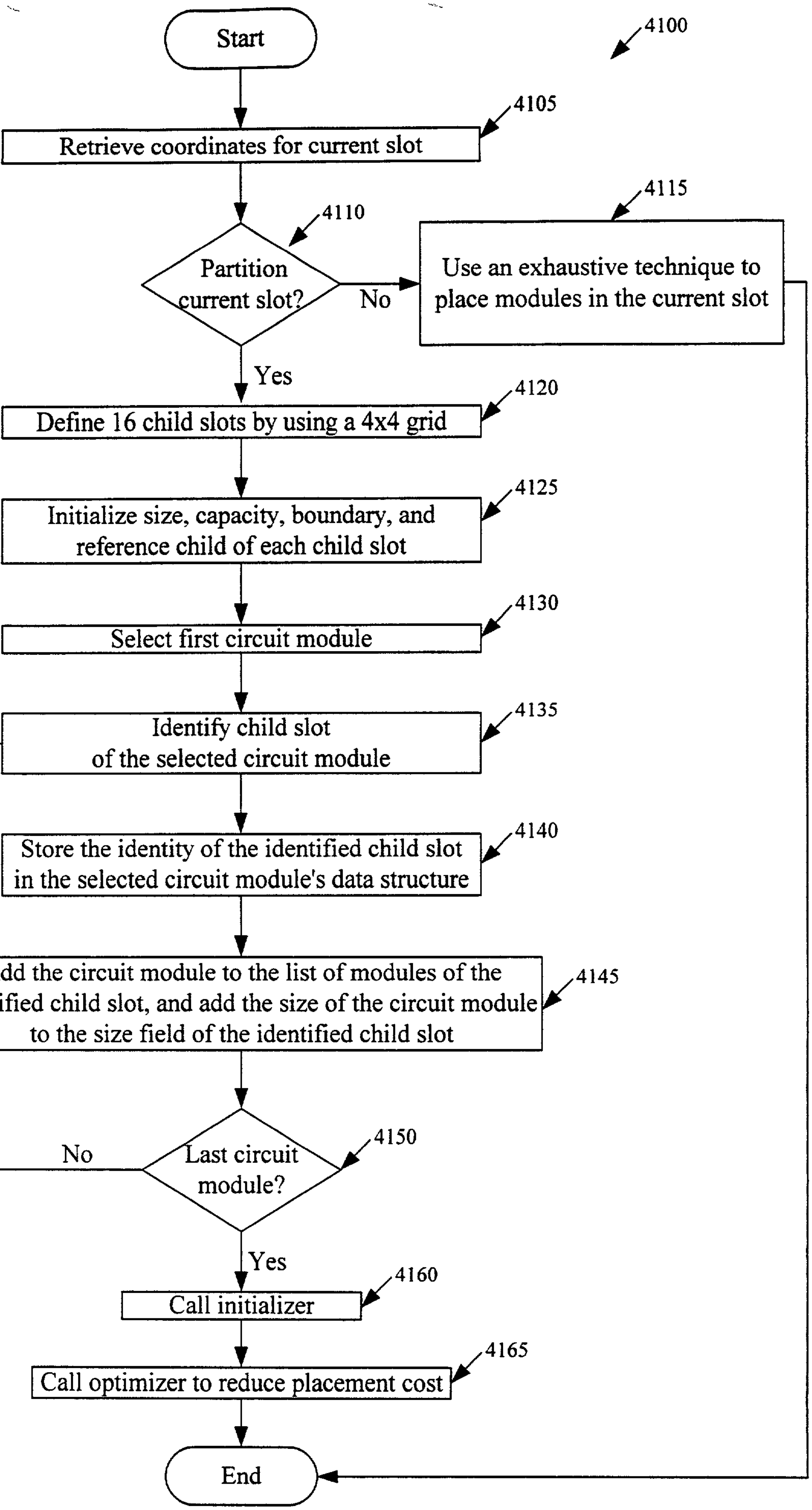

Start
4100
4105
Retrieve coordinates for current slot
4110
Partition current slot?
No
4115
Use an exhaustive technique to place modules in the current slot
Yes
4120
Define 16 child slots by using a 4x4 grid
4125
Initialize size, capacity, boundary, and reference child of each child slot
4130
Select first circuit module
4135
Identify child slot of the selected circuit module
4140
Store the identity of the identified child slot in the selected circuit module's data structure
4145
Add the circuit module to the list of modules of the identified child slot, and add the size of the circuit module to the size field of the identified child slot
4150
Last circuit module?
No
4155
Select next circuit module
Yes
4160
Call initializer
4165
Call optimizer to reduce placement cost
End

Figure 41

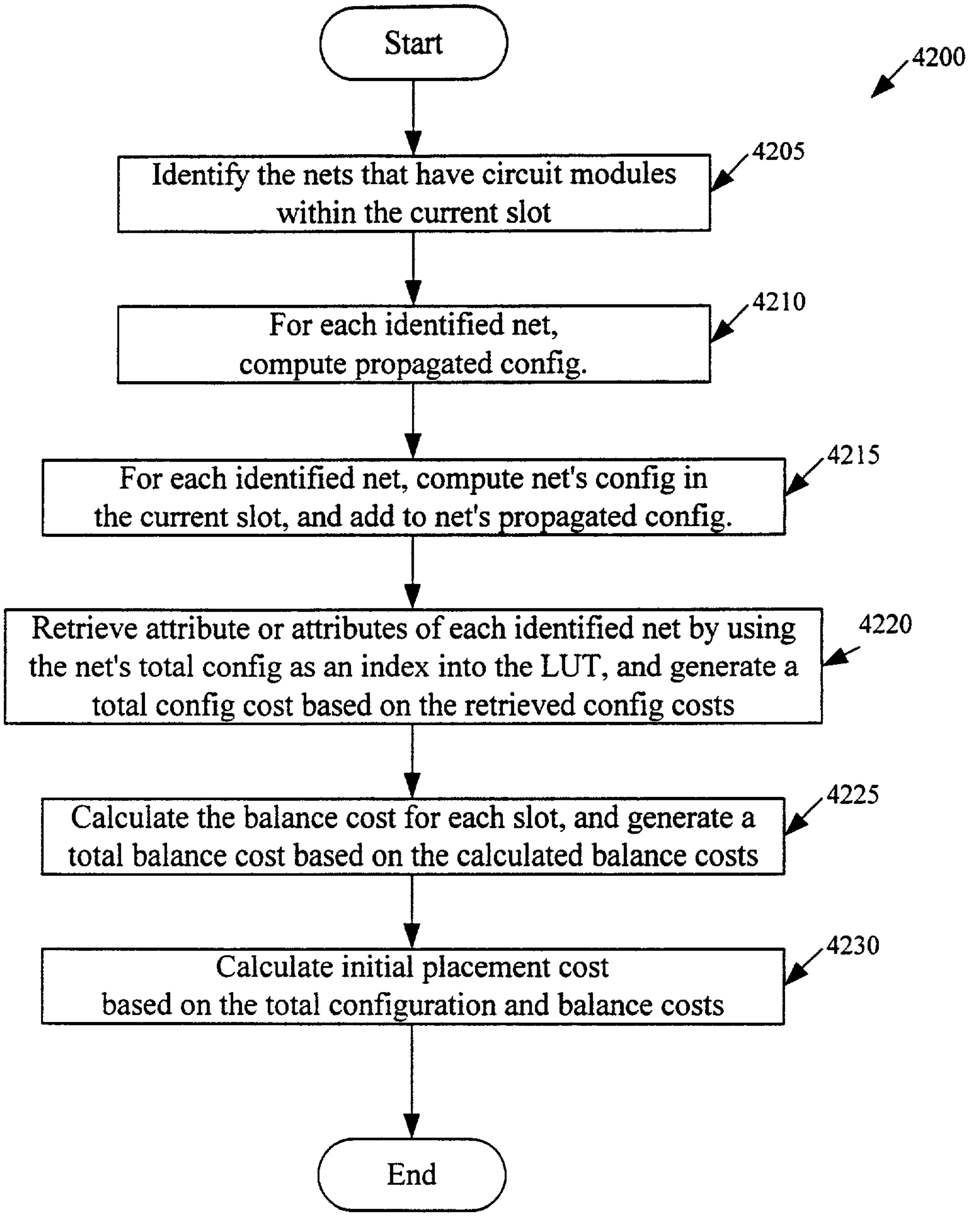
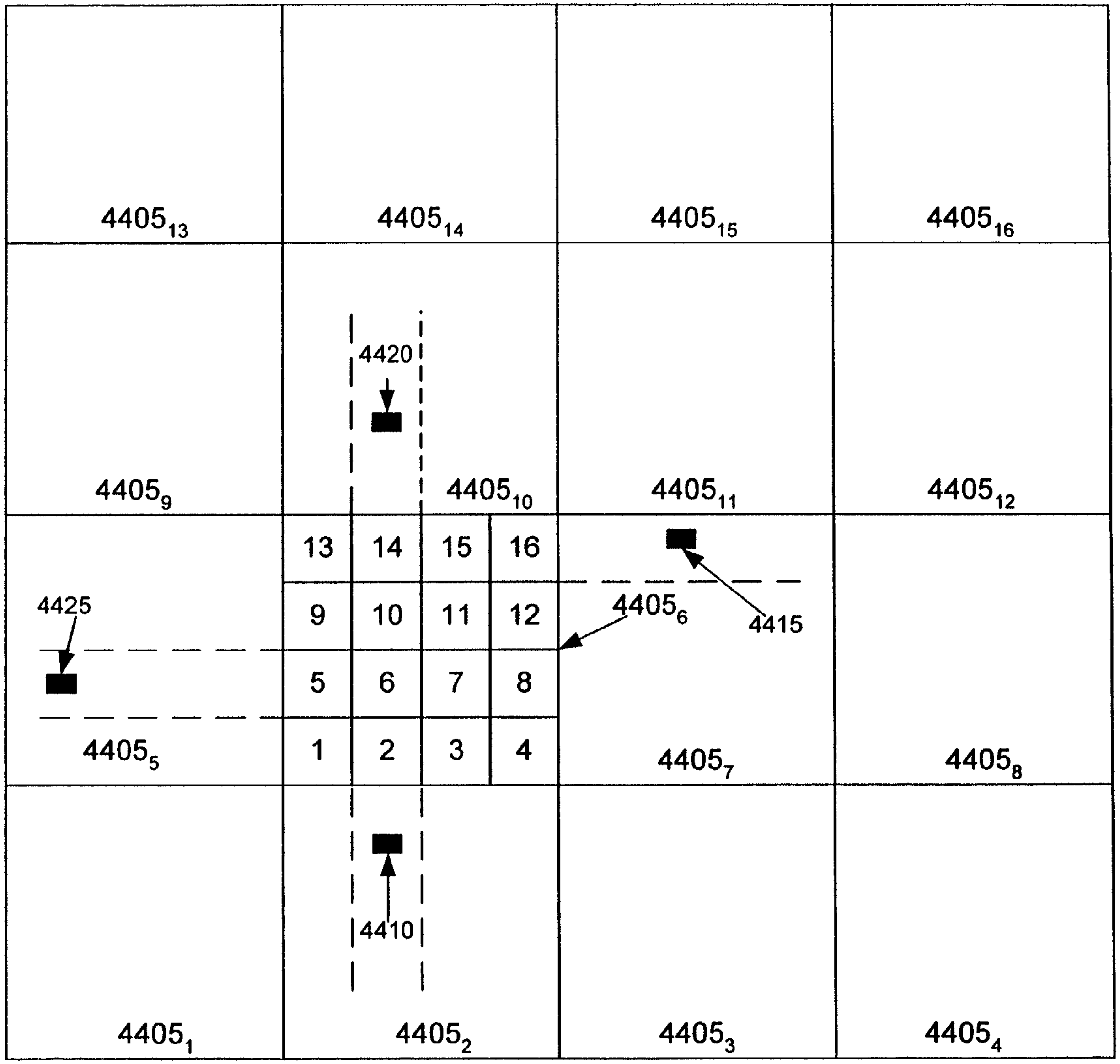

Start
4200
Identify the nets that have circuit modules within the current slot
4205
For each identified net, compute propagated config.
4210
For each identified net, compute net's config in the current slot, and add to net's propagated config.
4215
Retrieve attribute or attributes of each identified net by using the net's total config as an index into the LUT, and generate a total config cost based on the retrieved config costs
4220
Calculate the balance cost for each slot, and generate a total balance cost based on the calculated balance costs
4225
Calculate initial placement cost based on the total configuration and balance costs
4230
End

Figure 42

4300

$$\text{Data Structure} = [\, \sum_{net} F(netconfig, path1),\ \sum_{net} F(netconfig, path2),\ \sum_{net} F(netconfig, path3),\ \bullet\bullet\bullet\ \sum_{net} F(netconfig, path42)\ ]$$

Figure 43



4405_{13}
4405_{14}
4405_{15}
4405_{16}
4420
4405_{9}
4405_{10}
4405_{11}
4405_{12}
13
14
15
16
4425
9
10
11
12
4405_{6}
4415
5
6
7
8
4405_{5}
1
2
3
4
4405_{7}
4405_{8}
4410
4405_{1}
4405_{2}
4405_{3}
4405_{4}

Figure 44

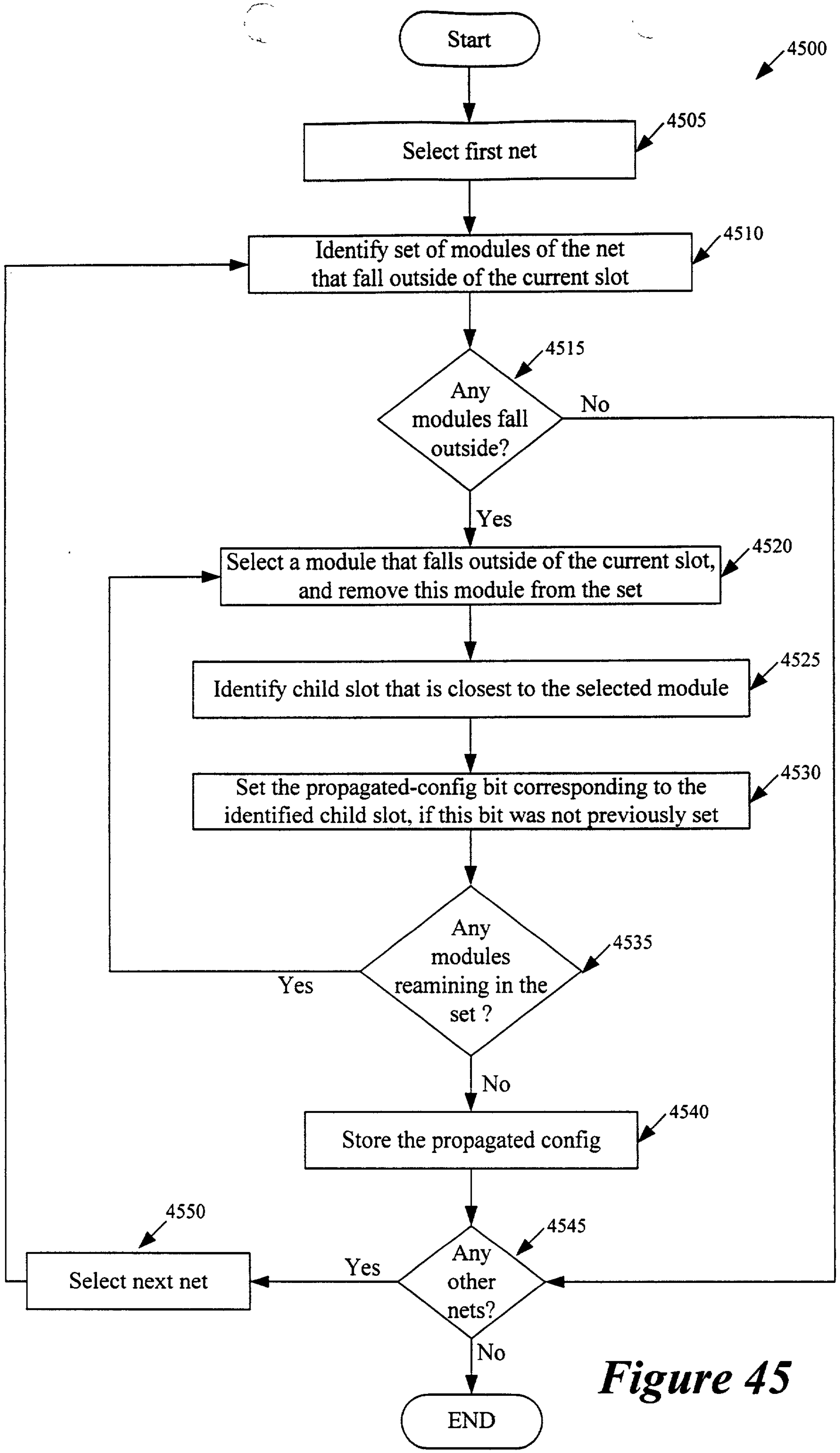

Start
4500
Select first net
4505
Identify set of modules of the net that fall outside of the current slot
4510
Any modules fall outside?
4515
No
Yes
Select a module that falls outside of the current slot, and remove this module from the set
4520
Identify child slot that is closest to the selected module
4525
Set the propagated-config bit corresponding to the identified child slot, if this bit was not previously set
4530
Any modules reamining in the set ?
4535
Yes
No
Store the propagated config
4540
Any other nets?
4545
Yes
Select next net
4550
No
END

Figure 45

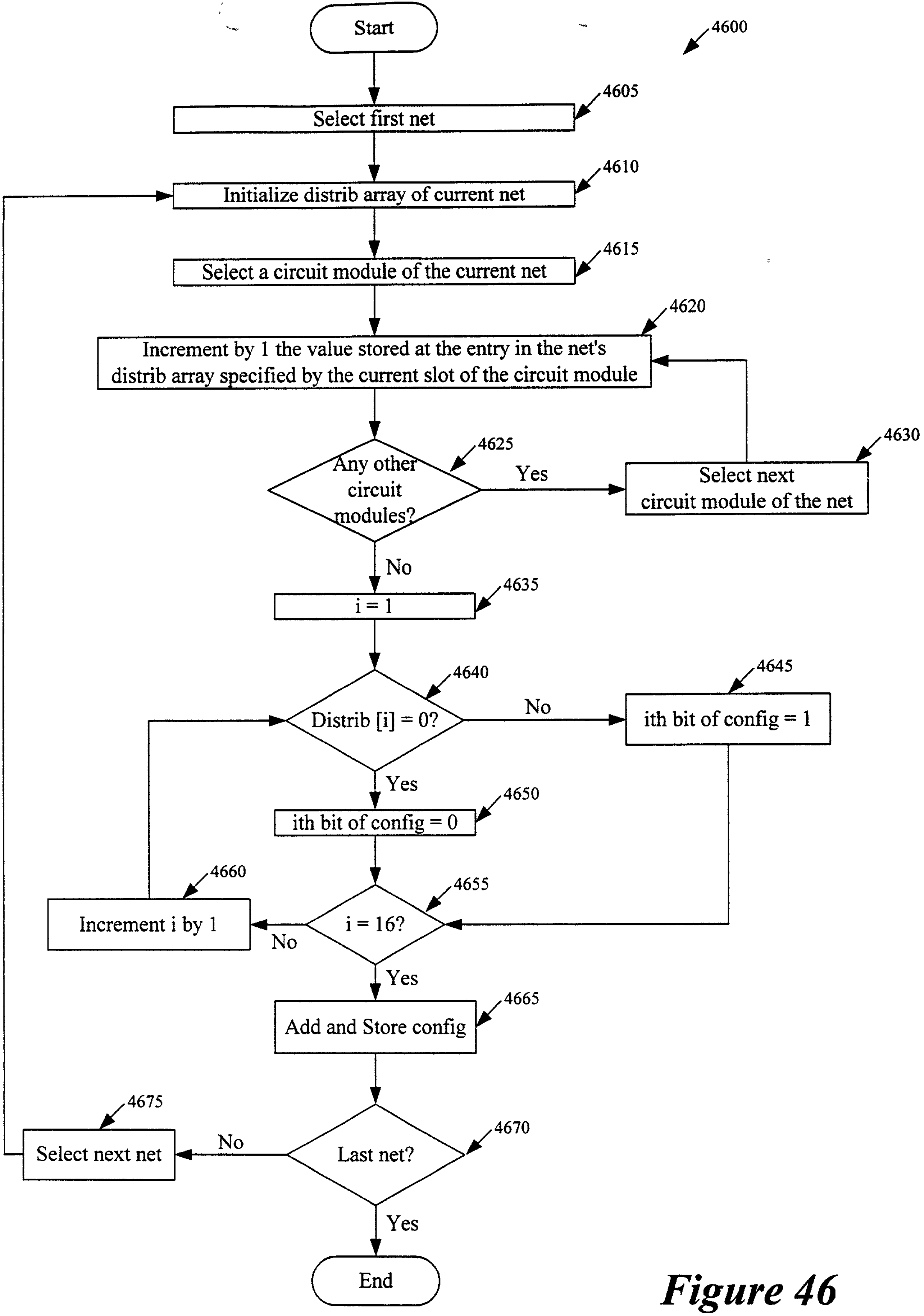

Start
4600
4605
Select first net
4610
Initialize distrib array of current net
4615
Select a circuit module of the current net
4620
Increment by 1 the value stored at the entry in the net's distrib array specified by the current slot of the circuit module
4625
Any other circuit modules?
Yes
4630
Select next circuit module of the net
No
4635
i = 1
4640
Distrib [i] = 0?
No
4645
ith bit of config = 1
Yes
4650
ith bit of config = 0
4660
Increment i by 1
4655
i = 16?
No
Yes
4665
Add and Store config
4675
Select next net
No
4670
Last net?
Yes
End

Figure 46

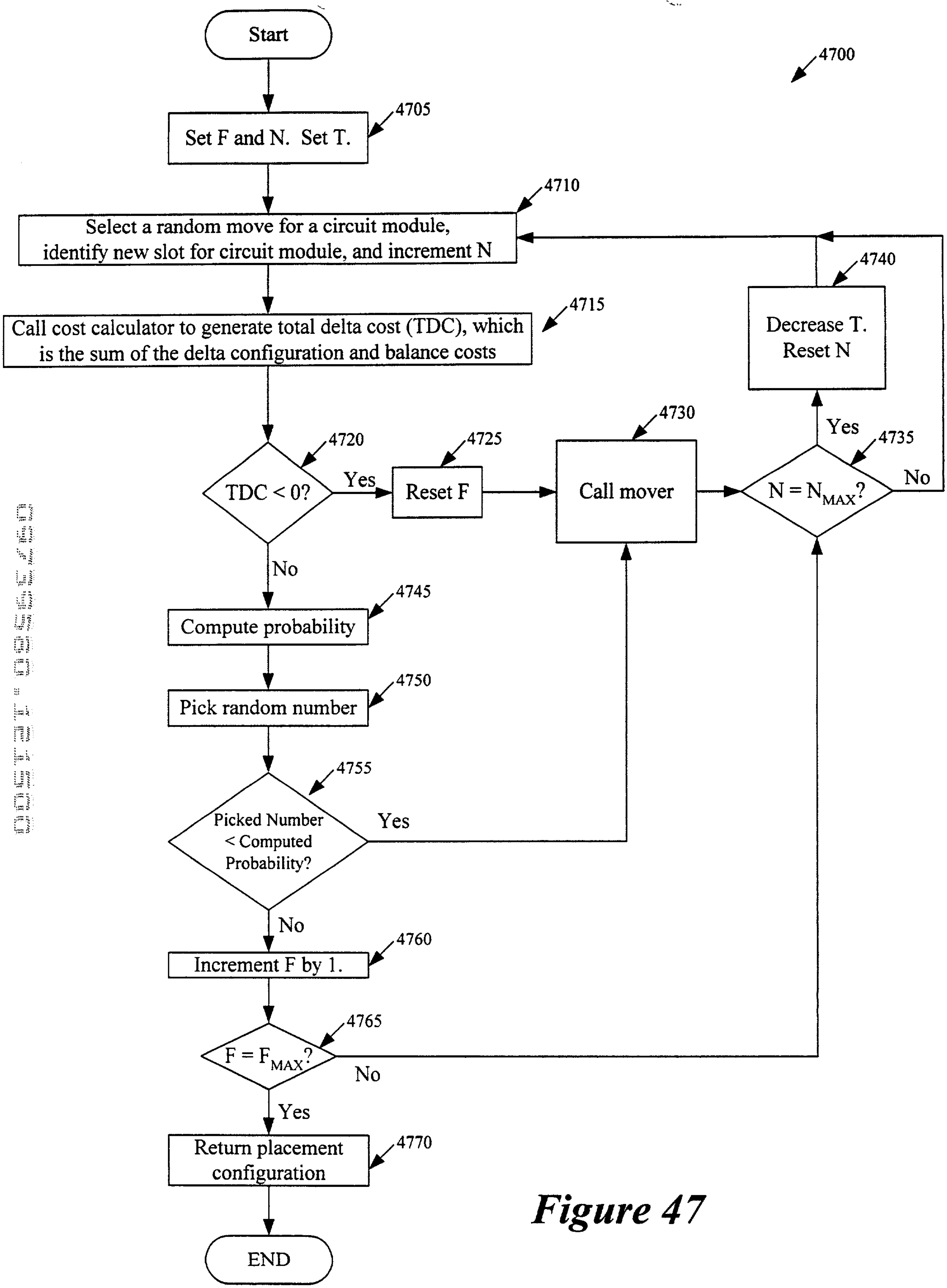

4700
Start
Set F and N. Set T.
4705
Select a random move for a circuit module, identify new slot for circuit module, and increment N
4710
Call cost calculator to generate total delta cost (TDC), which is the sum of the delta configuration and balance costs
4715
TDC < 0?
4720
Yes
Reset F
4725
Call mover
4730
$N = N_{MAX}$?
4735
No
Yes
Decrease T. Reset N
4740
No
Compute probability
4745
Pick random number
4750
Picked Number < Computed Probability?
4755
Yes
No
Increment F by 1.
4760
$F = F_{MAX}$?
4765
No
Yes
Return placement configuration
4770
END

Figure 47